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THE PLACE OF MOTION STUDY IN SCIENTIFIC MANAGEMENT*

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Mr. Chairman and Gentlemen:—

The subject of my paper is "The Place of Motion Study in Scientific Management." You undoubtedly realize that this is but a very small portion of Scientific Management, but, during the time that is alloted me for this paper, it will be impossible for me to give you anything more than a meagre description of this part of Scientific Management, with its relation to the other parts.

This I can best do by showing you graphically two plans of management. The first of these represents what is variously known as military or traditional management. As you will note here, each man is responsible to one man only above him, and is in charge of all below him. Thus, it is the custom for any man to come in contact with one man above him only, the line of authority being single and direct. Traditional management has been used for centuries in military organizations, and has also been used many times in religious organizations and political organizations. The division is by men, by grades of men rather than by functions.

The second chart represents functional or scientific management, or what would be called, but for objections by Dr. Taylor, the Taylor system of management. Here the division is by functions. The first functional division is the separation of the planning from the performing. Graphically, this separation is represented by the horizontal line. All functions above this line are of the planning, all functions below this line are of the performing. Note the functions shown on this chart, namely, four functions in the planning and four functions in the performing. Note also their relation to each other, and to the individual worker.

This chart shows one such worker represented by the lowest circle. There could be no objection to representing each individual worker by such a circle, but the relation of each such worker to those over him is exactly the same. Hence, the lowest circle is typical.

It will be noted that the worker receives orders directly from eight different foremen. You will, perhaps, suggest, on observing this, that it has often been said that no man can serve two masters.

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This holds good to-day, even in Scientific Management. But under Scientific Management the worker does not "serve eight masters" nor eight functional foremen, but, on the other hand, he receives help from eight different foremen or teachers. In this way, his case is not very different from that of the student who receives instruction from eight different professors, in eight different studies.

The four functions in the **planning** department are represented by

(1) Route Clerk and Order of Work Clerk
(2) Instruction Card Clerk
(3) Time and Cost Clerk
(4) Disciplinarian.

While I speak of each function as being represented by one person, as a matter of fact each function may include any number of individuals, according to the kind of work, and the number necessary so to perform that function as to eliminate all possible waste. Each

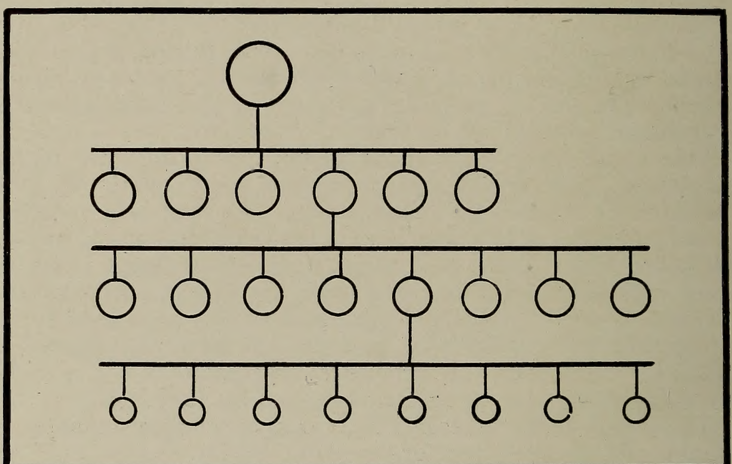

FIG. 1—Diagram illustrating the principle of Traditional or Military Management.

one of these four men of the four functions in the planning department, is supreme in his respective function. All deal directly with the worker, and all deal directly with the four functional foremen who are in the performing department.

Of the **performing** department we have four functions represented by

(5) Gang Boss
(6) Speed Boss
(7) Repair Boss
(8) Inspector.

These functions, like those of the planning department, are represented by as many men as the nature and amount of work justifies. All such representatives deal, as the chart indicates, directly both

The diagram on page 179 is incorrect. The proper figure is shown below.

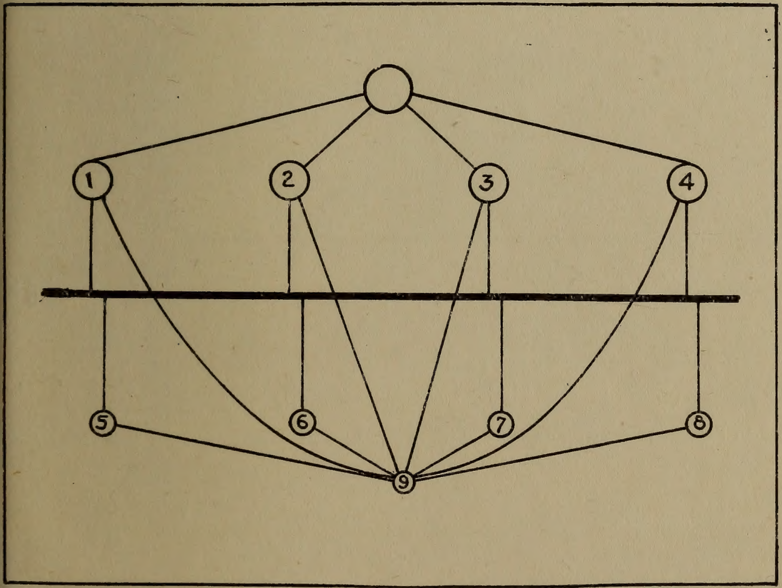

FIG. 2—Diagram illustrating the principle of Functional or Scientific Management.

with all individuals in the planning department. and with each individual worker.

I will now explain to you, briefly, the duties of the man handling each function, and at the same time call your attention to the subject of this paper, "Motion Study," which is a very small portion of the work of function No. 2 in the planning department under the instruction card clerk, and to the relation of this Motion Study to the other parts of Scientific Management, as shown in the chart.

Route Clerk

The duty of the route clerk is to plan in advance the path of each piece of material, worked and unworked, as it passes through the shop or as it is handled by each and every member of the or-

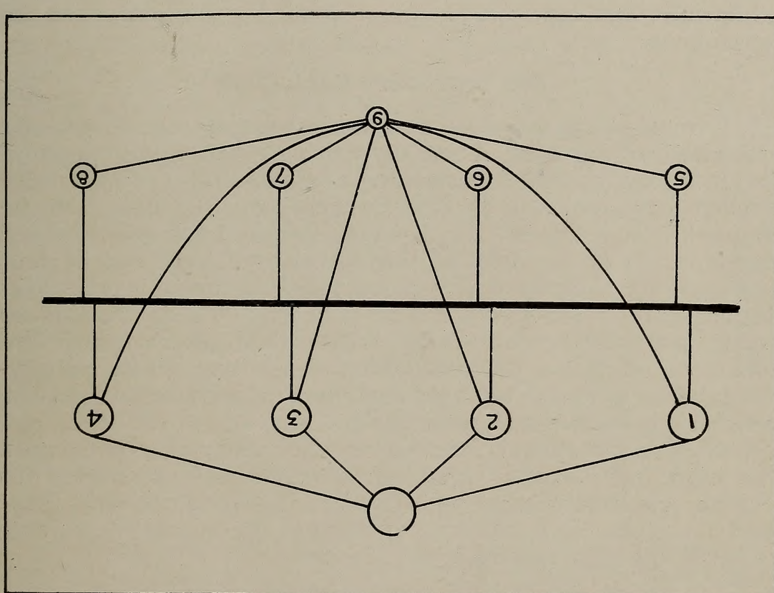

FIG. 2—Diagram illustrating the principle of Functional or Scientific Management.

ganization who has anything to do with it. He is to decide the three dimensions of the path, and the route that the material is to pass through, whether it is to go to the stores or into temporary storage piles, or directly through the shop as fast as it can be moved. His function is not simply to look after the details of the moving, but broadly, to determine the entire transportation career of the material. For example, in building operations, he would determine where the car was to be placed to be unloaded, where the material was to be unloaded, when it was to be moved into the building, and exactly what path it would follow across the floor, up the aeolevtrs, and to its final resting place.

Often the route clerk is able to greatly simplify the path of the materials, especially on large orders, by a rearrangement or routing of the machinery. I have had one case in my experience where it was cheaper, in a woodworking shop, to have the machinery placed on heavy pieces not attached to the floor, each operated by an individual motor, and to move it around into as nearly a straight line as possible, in order to accommodate the peculiarities of sequence of events of each particular order, when such order was large enough to warrant moving the machinery. The route clerk's duties, also, oftentimes consist of demanding a new path, that is, ordering that machinery not used be removed, so that he can route his material by a more economical method. After he has determined the exact path by which the material shall be routed, he embodies his conclusions in route charts and route sheets; these illustrate his orders graphically, and are worked out in detail by the instruction card department.

The Instruction Card Clerk

It must not be supposed that the instruction card function consists wholly of the work of actually writing out the instruction cards. This is the name of the function in general, and this function may be handled by several men of different capacity in the instruction card function, that is to say, the department may be divided into subfunctions. It is the duty of this function to work out in detail, that is to say to devise and construct, an instruction card for each element of the route sheets and route charts. The instruction card department must furnish in the greatest detail possible, such directions as will show two different classes of men their duties, namely—

(a) The worker, who must know how to perform the particular work shown on the instruction card,

(b) The functional foremen in the performing department, who must know exactly what he is to see that the worker does perform, and exactly what he is to teach the worker in order that he may so perform his work as to conform to the instruction card and to satisfy the man who made out the card.

The Time and Cost Clerk

After the worker has performed his work, a return of the time that it took him to do his work, together with its cost, goes to the time and cost clerk, who figures out the payroll, the bonuses, and the cost of performing each task.

The Disciplinarian

He is the man who handles all matters in the entire organization pertaining to disciplining. He must be a broad gauge man who is able to keep peace in the organization; to anticipate and prevent many disagreements and misunderstandings before they actually occur, and to arbitrate or judge fairly such disagreements as actually take place.

Now of the functions in the performing department:—

The Gang Boss

No. 5 is that of the gang boss. There may be many gang bosses in this department, in fact there are frequently five gang bosses of one trade. In such case, there would be an over-gang-boss in charge. There may be gang bosses in this function of twenty or thirty different trades, in fact of as many trades as are at work, or, possibly, one gang boss might look after two or more trades, or, on the other hand, there may be five gang bosses for one trade. The gang boss is not the "strong arm" type of man represented by the mate of the vessel of former days, who boasted that he could lick any man in the entire crew, and often did so for no other cause than to prove his words. He is now a man who can teach the worker the methods shown on the instruction card. His duty is to see that the worker performs the work required exactly as called for, and of the prescribed quality shown on the instruction card. In order to get his best work, and to enlist his zeal, it is usually necessary to pay him a bonus for each and every man under him who in turn earns his bonus, and a double bonus if every man in his gang earns the bonus. For example, suppose the gang boss received $3.00 per day, and had twenty men working under him, he would be paid, say, in round numbers, approximately 10 cents apiece for each man under him who received his bonus; and, if all twenty of the men received their bonus, he would receive a double bonus of 20 cents apiece for the entire gang.

You can readily see how such a plan of management as this will bring out co-operation as would no other plan, and I want to state here emphatically that there is nothing that can bring about results from Scientific Management, and the economies that it is possible to effect by it, except the hearty co-operation of the men. Without it, you have no Scientific Management.

Speed Boss

The speed boss, No. 6, regardless of the popular impression as to his duties, does not speed up the men, in fact he has very little to do with speeding the men. His duty is to see that the machinery moves at the exact speed called for on the instruction card. You can readily see that there is some one speed that is more desirable than any other speed; for example, the speed of a buzz planer or a circular saw is very dangerous when it is too slow, while on the other hand, the speed of a fly-wheel of an engine is very dangerous when it is too fast. The one that is the most desirable and safe is the speed that the instruction card man attempts to set on the instruction card, and it is the duty of the speed boss to see that the machinery runs at all times at exactly the prescribed speed. He not only shows the worker how he can make his machine run at the speed called for, but, if there is a question as to its being possible to run at this speed, he must be prepared to teach the worker by doing the work himself,or provide a man who can comply with the requirements of the instruction card.

Repair Boss

The next function is that of the repair boss. His duties consist principally of carrying out repairs and overhaulings, such as are called for on instruction cards that are given to him at regular, predetermined intervals. In this way breakdowns, as far as possible, are avoided. The repair boss, however, must be a resourceful man, prepared, in case of emergency, to jump in and repair any such breakdowns as may occur, even in the absence of precise directions or an instruction card.

Inspector

The eighth function is that of the inspector. His work is decidedly different from that of the inspector under the old type of management; for example, his inspection must result in constructive criticism, not destructive criticism. It is his duty to see that the material is rescued when it is not handled, or worked, exactly as called for on the instruction card.

Many times, under traditional management, the inspector comes around after the work is done, condemns it, and walks away, leaving it to others to see that the work is taken down, and, perhaps, carted from the premises. Under Scientific Management the inspector is required to stand near the worker when he is handling a new piece of work for the first time, in order to see that he thoroughly understands his work as it progresses. Thus the material is not spoiled. If the worker has a task of, say, fifty pieces, the inspector inspects the first piece most carefully, to make sure that he is satisfied that the worker knows exactly what he is to do, how he is to do it, and the quality prescribed by the instruction card.

The Workman

As for the individual worker, it will be seen that he receives not only an instruction card telling him what he is to do, how he is to do it, how fast he is expected to do it, the prescribed quality with which the work must be done, and how much pay over and above his usual day's wages he will surely get if he does all that is called for on his instruction card, but also, he receives personal teaching. The gang boss acts as his teacher constantly; the speed boss he can call on at all times to assist him with the speed; the repair boss co-operates with him to see that his machine is constantly kept in such repair that he can earn his bonus, and the inspector will also teach him at any time, and show him wherein he is making a deviation from the quality called for. Moreover, the functional foremen in the planning department are ready, at call, to explain their instructions. Thus he has every help that is possible, to enable him to earn the exceptionally high wages that are offered for Scientific Management. He is assured of the "square deal" from the foremen who are over him, and he always has the same opportunity to appeal to the disciplinarian, in case he is not being well treated, that a foreman would have in case the worker was not doing his

work as well as he could do it, or was not trying to co-operate with the other workers.

Having shown the principal functions of Scientific Management and their relation to each other and to the individual worker, we are now ready to concentrate on Motion Study.

The three most oblivious economies to be obtained by Motion Study would be to use (1) the fewest motions, (2) the shortest motions, and (3) the least fatiguing motions; but these, however, are but a small part of the list of savings that could be obtained.

For example, in one organization with which I have recently been working, I found a man who had been working in the same shop for over twenty years whose duties consisted of doing work that required his hands to be within six inches of the floor on which he stood, practically all day, except when he was resting. This man was one of the tallest men that I ever saw, he surely was more than 6 feet 6 ins. On the other hand, I found in the storage department one of the shortest men I ever saw, who was piling cases up in a pile about 7 feet high. Now it must readily be seen that there are other things to be considered, as for example, the selection of the men that they may make, naturally, the best adapted motions for the work.

Motion Study is a part of the function No. 2 of the planning department. It is here necessary to go back a little way and see what it is that the instruction card man is supposed to do. His duty first of all is to devise a way that is the most economical and the least wasteful of any way that can be devised, and the nearer that he can get to perfection the better he is in his function. The nearer he devises a method that is fundamentally right the more scientifically can rates be set. It must be remembered that under Scientific Management the rate is never cut. Any manager who is familiar with the evil by-products of cutting the rate on piece work will readily understand the tremendous benefits that accrue from any system where the rates are so fixed that not only the rate need never be cut, but that there is no incentive to ever cut the rate. Cutting the rate results in scientific loafing, which is quite the opposite of hearty co-operation, and, as I have said before, without hearty co-operation you cannot have the great savings that make it possible to pay the unusually high wages to the workmen, and at the same time provide the unusually low production costs to the employer.

Motion Study is so intimately related to time study that it is quite difficult to specify exactly where one begins and the other leaves off. Perhaps the best way to describe it would be to say that Motion Study is for the purpose of seeing that the process is right, and time study is for the purpose of determining how long each element of the process will take, and how much time must be devoted to rest for overcoming fatigue.

Motion Study theoretically is supposed to furnish measurable units for time study, but the units are so small that they have not, until recently, been timeable.

I expect to place a mechanical device on the market within the

next two months that will time accurately the motions of the workmen down to the thousandth of a minute without any of the inaccuracy that comes from the human element in the observing. For twenty-five years I have been advocating the method of teaching right motions first instead of teaching quality of output first. You undoubtedly will realize that it takes considerable courage (or else positive proof) to advocate openly neglecting all thought of the quality temporarily for the sake of great precision of right motions.

Only a short time ago I told two prominent members of the A.S.M.E. that I had had unusual success with teaching boys and men new methods by using great care in having them use the right motions first and then the right motions with increasing speed until the maximum speed was reached and to give no thought whatever, meantime, to the quality. The answer of these two gentlemen was —that if that was the way that I did my work I couldn't expect ever to do any work with them.

Now it is quite difficult, if not actually impossible, to make some people realize that great precision of motions is identical to giving great attention to quality of output, for if the motions have sufficient precision the quality will undoubtedly have also the greatest precision that would be obtainable by that particular workman. I think that one reason that the great benefits that can be derived from emphasizing teaching the right motions first, was not recognized, was because the teachers of the trades did not know what the right motions were. Ordinary photographs, stereoscopic photographs and motion picture photographs now enable us to recognize and determine, separate and measure the various motions with great accuracy, and the results are quicker teaching, automaticity of motions, habits of right motions and less fatigue and less percentages of fatigue. These all permit much faster motions.

There are a great many other reasons why motions should be standardized, and if they are standardized, it goes without saying that the motions should be the right motions. One of the reasons for taking great care in standardizing motions is that it reduces enormously the amount of time study that must be taken, and time-study is at best an expensive and somewhat tedious process. It is much more necessary that we have a standard method for each process early, than that we wait until we devise the best possible methods; however, it is, of course, desirable that the standard process shall be built up from the best known motions at the time that it is standardized.

Now there are a great many variables that affect the motions, and I give here variables as cited in the first edition of Motion Study. This is by no means a complete list as there are as many more variables recognized to-day, but this list will give you a fair idea of what we mean by the "variables that affect the motions," and oftentimes it will be found that the variables make necessary or advisable the complete elimination of certain motions that were considered necessary before due consideration was given to the variables. These variables may be preferably divided into three

kinds; (1) the variables of the worker; (2) the variables of the tools, equipment, appliances; and (3) the variables of the motion itself.

Variables of the Worker

Anatomy, brawn, contentment, creed, earning power, experience, fatigue, habits, health, mode of living, nutrition, size, skill, temperament, training.

Variables of the Motion

Acceleration, automaticity, combination with other motions and sequence, cost, direction, effectiveness, foot-pounds of work accomplished, length, necessity, path, play for position, speed.

Variables of the Surrounding Equipment and Tools

Appliances, clothes, colors, entertainment, music, reading, heating, cooling, ventilation, lighting, quality of material, reward and punishment, size of unit moved, special fatigue-eliminating devices, surroundings, tools, union rules, weight of unit moved.

The scheme of Motion Study is to discover perfection and to perpetuate it automatically.

Scientific Management has been extremely slow in making an advance in the industries and the principal reason for this is that the scientific managers have been obliged to train their own men. There is no school at the present time that has sent out young men who were even familiar with the vocabulary of Scientific Management, so far as I and my associates have been able to determine.

After having determined the right motions, the right times for the motions, and having grouped them into cycles of elements, of subdivisions, of processes, we then determine the amount of rest that must be allowed for overcoming fatigue, and then we have the standard task for the standard man, and here I must tell you about the difference between the "standard man," the "first-class man" and the "given man." The motions and the time of motions are taken on the standard man; that is, the best man procurable, the best man that we can get to be observed.

While motions and the time of motions have been determined by observing the best men procurable, it is not to be expected that other men will be obtained who will be as good as the best man picked out for this purpose. The first-class man is the man who is best adapted to this particular work; that is to say, the best man adapted to do this work continually and thrive. The first-class men are obtained from the given men. Some find that they cannot do the work, and either become discouraged or assigned to other work before they get discouraged. Many people think that the hard task makes an unwarrantable hardship upon the worker, but this is not so, for Scientific Management contemplates having each man work at the highest class of work for which he is mentally and physically and by experience able to work at continuously and thrive. The interdependence of all the men from the individual workman to

the highest man in the planning department is so noticeable that it is necessary that those men only are picked out to do the work who are capable of doing it so as not to delay those that follow him in a dependent sequence of operation. If an inefficient man who could not be depended upon to do a certain predetermined piece of work were permitted to work at a place where he failed to perform his task day after day, he would interfere with all those men who followed him earning unusually high wages; therefore it would not be fair to the other men to permit any man to work at any job that he was not fitted to do continuously to the quantity called for in the task.

Now that there is so much literature on the subject of Scientific Management why is it a fact that the progress of Scientific Management has been so remarkably slow? The answer to that question is that many people who are thoroughly familiar with the duties of the men and the various functions are not familiar with the pitfalls that are ever present in its installation. As I have said twice before, the entire scheme is dependent upon the hearty co-operation of everybody in the organization, and workmen everywhere have been deceived so many times in the past that they are naturally suspicious that this Scientific Management is nothing more nor less than a new fraudulent confidence game presented to them in a more deceptive form than they have ever seen, and they believe that it is for their best interests to smother while it is still young.

On the other hand, there never has been a case where Scientific Management has been put in properly that all the workmen did not realize that it was much better for them than any form of management that they had ever seen. To those of you who are interested in Scientific Management I respectfully suggest that it would pay you to go to Philadelphia and to see the Tabor Mfg. Co., and the Link Belt Co., who have had the Taylor System longer than any other concern in the country.

Now that there has been many successful demonstrations of Scientific Management where the workers receive much higher wages than ever before and where the costs of production are lower than ever experienced by manufacturers before, it seems extremely unfortunate that the terrible wastes that are going on where Scientific Management is not in operation, should continue, and I therefore hope that this university will consider seriously the study of Scientific Management not only for the education of the young men who are going out in the world as engineers, but also with the idea of establishing a permanent station for the collection of Motion Study and time study data working in co-operation with similar colleges in the United States and Canada and also with various organizations who are doing good work toward investigating and disseminating information regarding Scientific Management, particularly the Society to Promote the Science of Management.

The problem is too great for any one firm, corporation, or college; in fact, this is work in which all English speaking nations should unite

the same as we have already done in our investigations of matters pertaining to medicine, agriculture, and the animal industries.

I hope to see an international bureau for the study, for the collection, study cataloguing and dissemination of data relating to Scientific Management that the workmen of all countries may be benefited and that unnecessary wastes may be eliminated.

I fully appreciate the honor of having the opportunity to present this paper to you, for we recognize the University of Toronto as one of the foremost educational forces on the Western hemisphere.

MALLET LOCOMOTIVES FOR THE CANADIAN PACIFIC RAILWAY

By Frederick H. Moody, B.A. Sc.
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While this paper will centre on the recent construction of a series of Mallet articulated compound locomotives by the Canadian Pacific Railway, a little consideration of just what the Mallet compound is, where it originated, and what is being done towards its promotion in the United States and Canada, will first be essential to a fuller understanding of the conditions this newer and much mooted type of locomotive is being introduced to meet.

For those who are not familiar with the Mallet, it may be said that a Frenchman of that name was the first to design and successfully construct a jointed or articulated locomotive, a good example of such a type being shown in Figure 1. The word "articulated" is self-explanatory. The dictionary defines it, to "joint or to unit by a joint." Thus, a Mallet articulated locomotive is a jointed structure, independent units operating together in unison from a central control.

Mallet locomotives have been in more or less general use on the Continent for many years, the exact date being unknown to the writer. But the first one to be constructed in America was that built by the American Locomotive Co. to the order of the Baltimore & Ohio Railroad. Being of a radically different design from anything heretofore produced on this side of the water, it occasioned widespread comment, the general opinion being that it was "freakish" and that its maintenance would be excessive, if, in fact it could be operated at all. Such was not the case as the successful operation of that and numerous other locomotives of a similar type bear testimony. In fact, statistics gathered by the builders of that locomotive last year, showed that an aggregate of over 400 Mallets were in successful operation on 29 of the leading roads of America. This particular B. & O. locomotive showed a considerable saving, being able to replace two heavy consolidation locomotives that had previously been required to handle the same trains.

Figure 1 shows a heavy Mallet—one of a set of three—built in 1907 for the Erie Rd. by the American Locomotive Co at a time

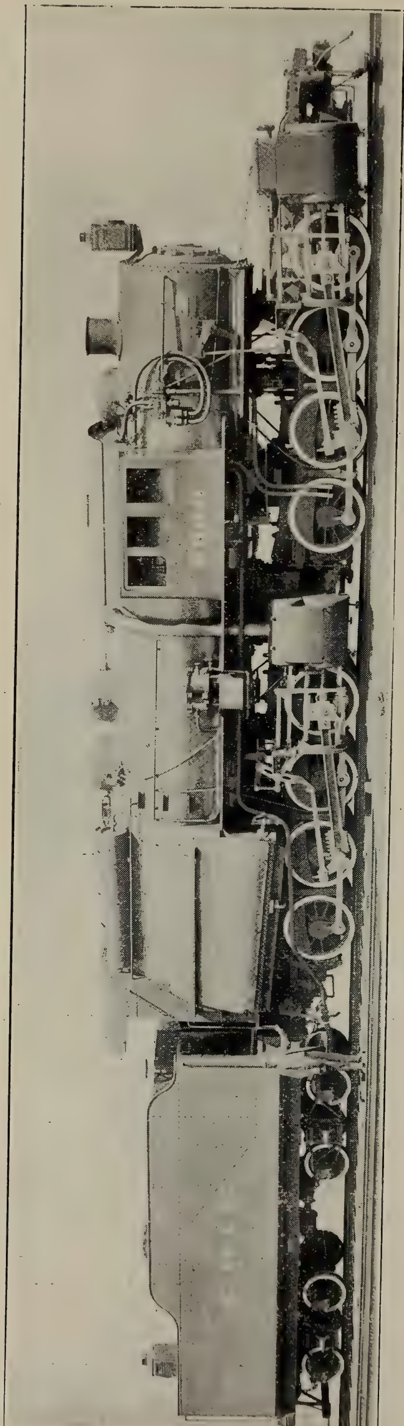

FIG. 1—An Early Mallet Locomotive for the Baltimore and Ohio Railroad.

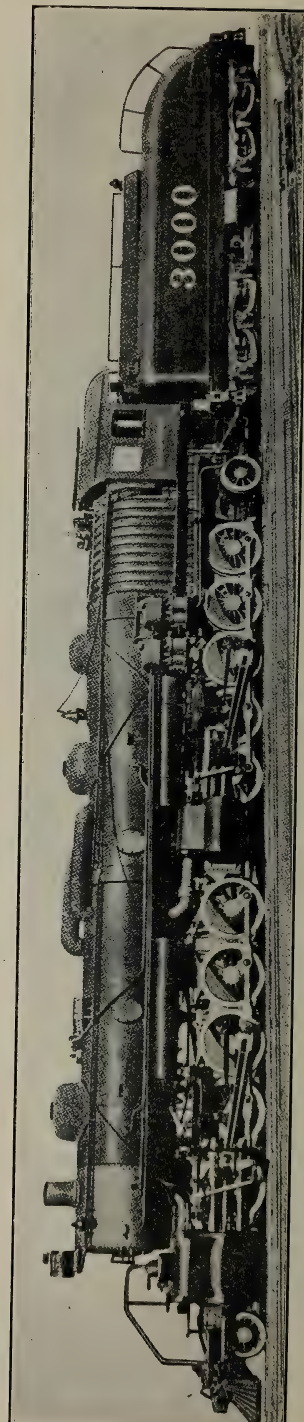

FIG. 3—Most Powerful Locomotive in the World.

when the writer happened to be connected with that firm. At that time, these locomotives were the heaviest in the world, the engine alone running up to a matter of 410,000 pounds, or 205 tons. As shall later be seen this record has since been greatly outdistanced.

Let us next consider the reasons for the introduction of such enormously powerful machines. Consider a medium-sized consolidation locomotive, working to its full capacity on a road with a ruling grade not exceeding say 0.5 per cent. This one locomotive would be perfectly capable of handling a given train under all the normal conditions to which it would be subjected on that division. But supposing, as in the case of a number of the United States trunk roads, some obstacle such as the Alleghany Mountains has to be surmounted; in this case there is a stretch of road varying in length from ten to fifty miles, with a heavy grade. This makes one of two things necessary; either the train must be broken up, into smaller units, or else be given assistance. The former may fairly be counted out, the cost and inconvenience being prohibitive, for a large part of the traffic is routed straight through from the West in solid trains; assistance is thus resorted to. On the roads cited, the grades at these heavy points are such as to require at least two locomotives similar in size to that handling the train up to that point, to act as pushers in assisting the train over the heavy grades and curves. This requires a double crew in the pusher service, increasing operating costs.

The question naturally arises—why not build larger locomotives of the same type, so as to require only one to act as pusher? The factor of limitations here enters. Were the locomotive to operate on a straight piece of track free from all curves, enlarging a rigid frame freight locomotive by lengthening it might be resorted to, but where curves are to be negotiated, a limitation is set to the length to which the wheel base may be increased. Likewise, the possibility of increasing the size upward and outward is held within bounds by the clearance gauge set by the engineering staff of the road, and by the fact that the axle loads must not exceed a certain figure —60,000 pounds, being considered an undesirable maximum. Consequently, any increase in locomotive size must be lengthwise, which, as just shown, is impossible with a rigid frame.

Hence, a flexible frame becomes necessary, resulting in the present universal adaptation of the Mallet where heavy freight-handling units are required. In fact, there are instances where they have been very successfully used in heavy passenger service.

As may be seen from the photograph, Figure 1,a Mallet locomotive really consists of two separate and distinct engine units under one steam-generating or boiler unit, the rear frame and boiler forming a rigid connection, with the front frame articulated or hinged, so to speak, to the rear one and free to swing from side to side under the forward part of the boiler when taking curves. This is shown to advantage in Figure 2, where a Mallet locomotive is shown standing on a curve, the front frame being shown swung over to one side. It can readily be seen that the whole locomotive thus becomes very flexible in operation.

There are other uses for the Mallet besides that of pusher service, increase in traffic over a given division by the increase in train size being probably the principal one. As a special instance of this, an installation of Mallets on the Pennsylvania division of the New York Central Lines may be cited. In this instance, 26 articulated engines replaced 60 consolidations, the overloaded single-track capacity of 1,000 cars every twenty-four hours being easily increased 40 per cent., making the capacity 1,400 cars per day. Those familiar with railroad conditions will realize what a tremendous volume of traffic this is for a single track road. A further saving is here obtained,

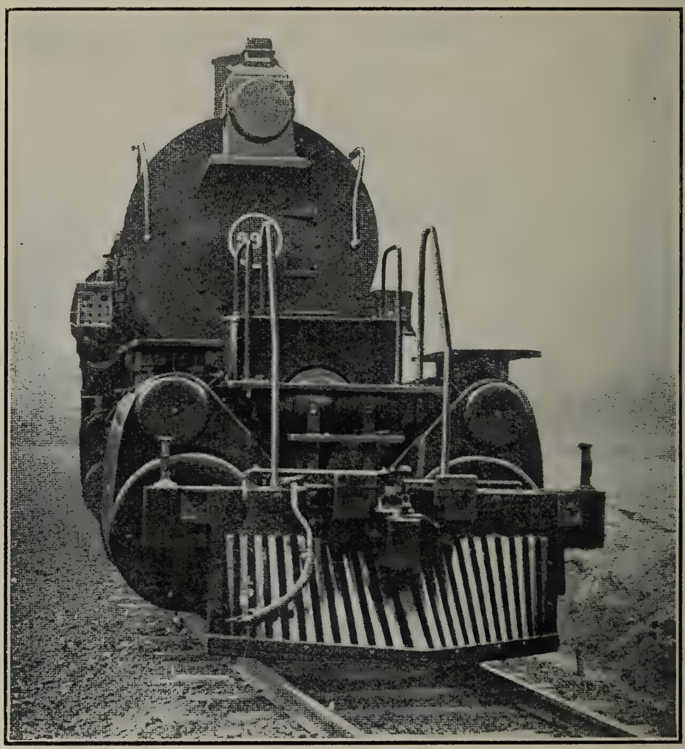

FIG. 2—Flexibility of a Mallet in taking a curve.

the necessity of double-tracking the division being indefinitely postponed.

Before finally coming to the specific object of this paper—a description of new Mallets for the C.P.R.—another example of Mallet practice will be given. This example illustrated in Figure 3, constitutes the most powerful locomotive in the world, weighing as it does, 616,000 pounds—850,000 pounds including the tender. The wheel base of engine and tender is over 108 feet. This locomotive, constructed and put in operation by the Sante Fe last year,

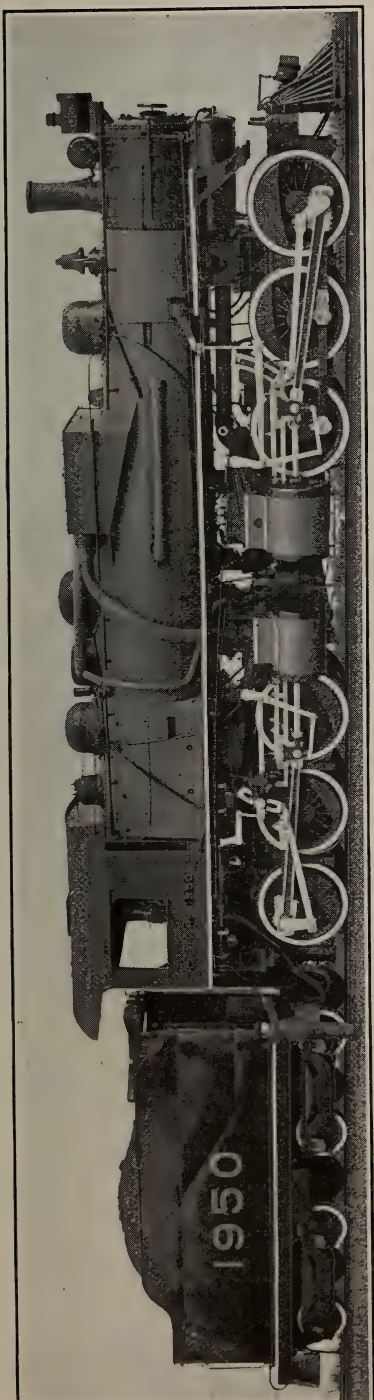

FIG. 4.—Experimental Mallet for the C.P.R.

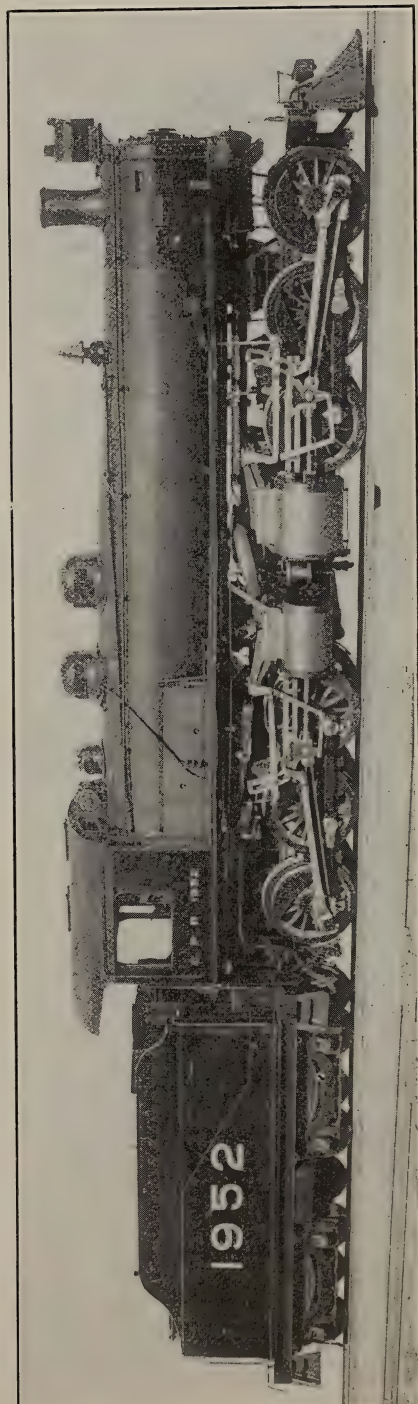

FIG. 8—C.P.R. Mallet designed on Basis of Tests on Experimental Mallet.

forms a marked contrast to the Erie locomotive mentioned earlier as being the largest locomotive extant at that time. This newer engine, constructed just four years later, marks an increase in size of more than 50 per cent. While it is scarcely safe to make any positive assertions, it would seem as if the limit had been reached,

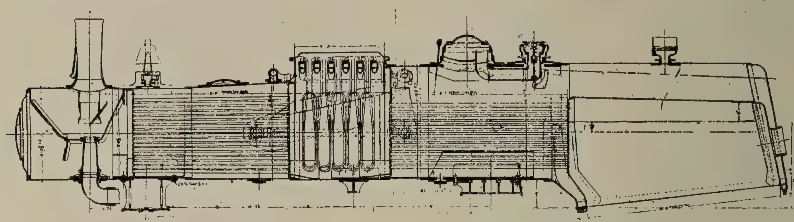

FIG. 5—Boiler of Experimental Mallet.

and that at least this locomotive would stand without peer for many years to come.

Coming nearer home, the activities of the Canadian Pacific Railway will next be considered. This very progressive road, always in the van in new motive power equipment, investigated the value

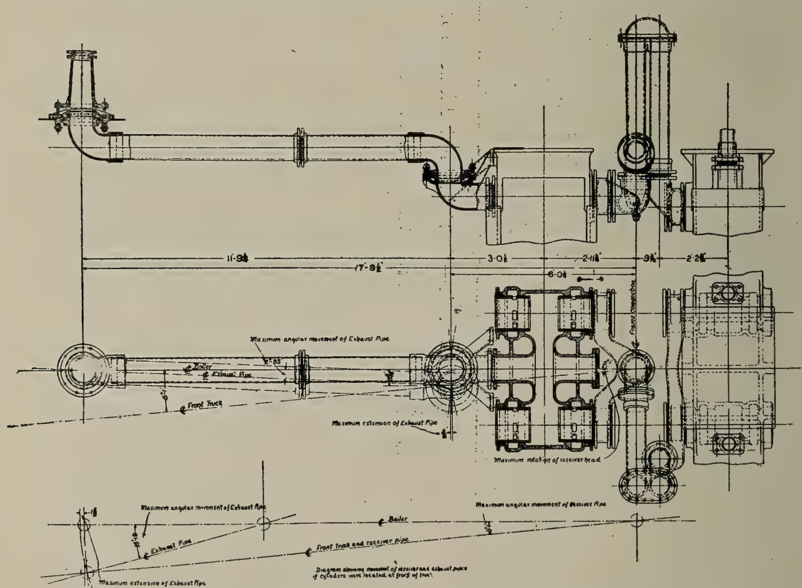

FIG. 6—Steam Piping of Experimental Mallet.

of the Mallets by building an experimental one, Figure 4, to its own designs in its Angus shops. The object in mind was to produce a locomotive that could more economically handle freight traffic through the mountain sections of the British Columbia division where gradients up to 2.45, and 15-degree curves are to be nego-

tiated. The locomotives previously handling the traffic were 185,000 pound consolidations, capable of handling 424-ton trains. This Mallet was designed to handle trains up to 700 tons, and from tests to be mentioned later, the expectations were fully realized.

This locomotive was in the nature of an experiment, so in order to ascertain the correctness of certain theoretical premises held by the designers, some rather novel features of design were embodied in the construction. Principal among these were the boiler construction, and cylinder arrangement. Figure 5 shows this novel boiler. Instead of a plain tubular barrel section, the latter is divided into three sections—boiler proper, superheater compartment and feed-water heater. The water, first heated in the forward water-

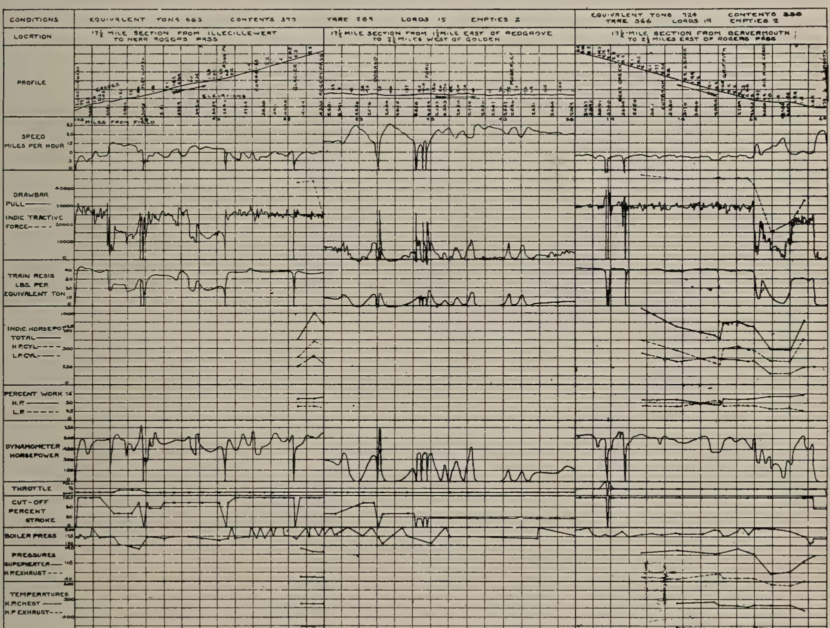

FIG. 7—Test Curves of Experimental Mallet.

heating section, passes back through equalizer pipes to the steam-generating section, from whence the saturated steam passes to headers in the intermediate chamber, downwardly projecting superheater units bringing the saturated steam into contact with the hot flue gases. The superheated steam then passes on into the cylinders.

Referring again to Figure 4, it will be noticed that the cylinder arrangement is different to that in common use on Mallets, forming a radical departure. Both pairs of cylinders, it will be noticed, are at the centre of the locomotive, head to head. The value of this arrangement can best be appreciated by reference to the piping diagram, Figure 6. The steam in the first place in exhausting from the high to the low pressure cylinders, passes across the inter-

vening gap through a swivel pipe joint, to the moveable front engine cylinder. This swivel pipe joint is located directly over the pin connection between frame units. When piping the steam from the low pressure cylinders to the exhaust stack, provision must be made for allowing the exhaust pipe to lengthen as the front truck swings off centre, the angular displacement causing the distance between pipe centres to slightly increase. Now, had the cylinders been well forward, the relative movement of pipe centres would have been proportionally greater, making it necessary to introduce an exhaust pipe capable of meeting greater extensions, and to also have greater swiveling scope.

This locomotive was thoroughly tested out under both special and service conditions. The earlier special tests were made near the shops at Montreal where a gradient of 1.5 was to be had. These tests gave sufficient data to lead to a slight remodelling of the engine.

Following this, however, a very thorough series of tests under the service conditions for which the locomotive was designed, were conducted on the 130-mile stretch of mountain track from Field to Revelstoke, B.C. The more instructive of the results obtained are plotted in the curves shown in Figure 7.

All this experimental work gave the Canadian Pacific Railway mechanical department a great deal of data upon which to base the design of a further series of five Mallets, a description of which is embodied herewith. This new series, which has only recently been finally completed, consists of 4 compounds, 1951-4, and one simple 1955, all of the same general design. The general appearance of the compound Mallets of the series is shown in the accompanying illustration, Figure 8, while Figure 9 outlines the locomotive construction more in detail.

The following table gives the principal dimensions:

Type	0-6-6-0
Gauge	4 ft. 8½ ins.
Service	Pusher
Fuel	bituminous coal
Tractive power	57,000 lbs.
Weight, drivers	259,000 lbs.
Weight, total	259,000 lbs.
Wheel base, front engine	10 ft. 4 ins.
Wheel base, rear engine	10 ft. 4 ins.
Wheel base, total, engine	35 ft. 2 ins.
Wheel base, engine and tender	60 ft. 7 ins.
Weight on drivers ÷ tractive effort	4.54
Tract. effort × dia. drivers ÷ equiv. heat. surf	921
Equiv. heat. surf. × grate area	62
Weight on drivers ÷ equiv. heat. surf	72
Cylinders, h.p.	23 x 26 ins.
Cylinders, l.p.	34 x 26 ins.
Cylinders (simple engine 1955 only)	20 x 26 ins.
Valves. h.p.	11 in. piston
Valves. l.p.	12 in. piston
Driving wheels. dia.	58 ins.
Driving axles. main. 9½ x 12 ins.; others	9 x 12 ins.
Boiler	Radial stayed, wagon top
Pressure	200 lbs.
Firebox, size	120 x 69⅞ ins.
Firebox, sheets	5-16, ⅜, 1-12 and 7-16 ins.
Firebox, water spaces, sides, 4½ ins.; throat, 5 ins.; back,	3½ins.
Tubes	154 2¼-in. dia.; 16 2-in. dia.; and 22 5¼-in. dia.
Tubes, length between sheets	20 ft. 1½ ins.
Heating surface, tubes	2,589 sq. ft.
Heating surface, firebox	180 sq. ft.

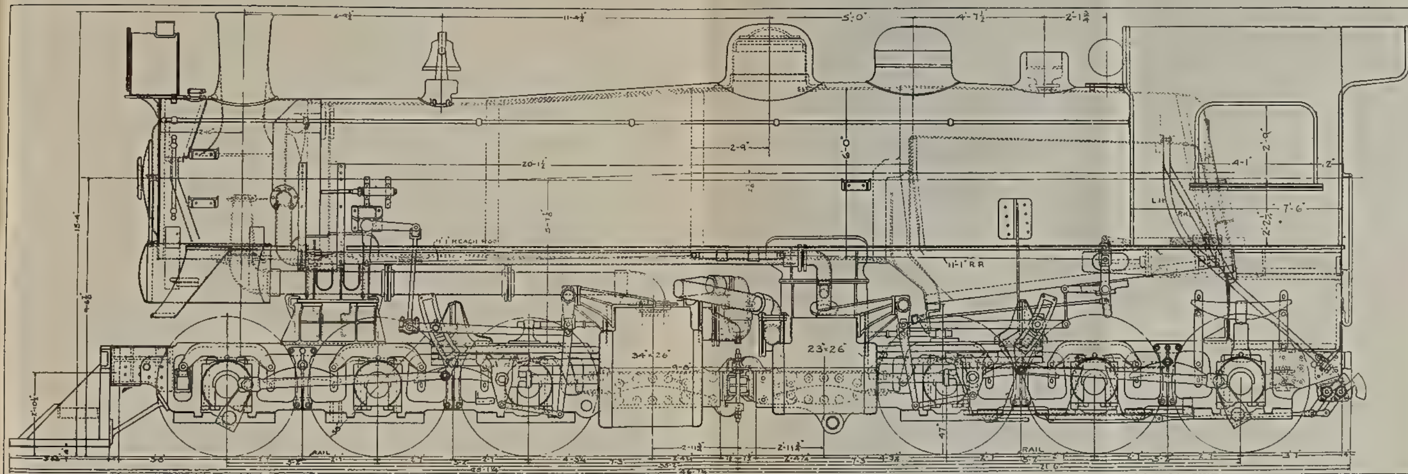

FIG. 9—Elevation of New Mallet.

Heating surface, total	2,769 sq. ft.
Superheating surface	548 sq. ft.
Equiv. heat. surf. (= total heat. surf. + super. surf. × 1.5)	3,591 sq. ft.
Grate area	58 sq. ft.
Tender tank, kind	semi-water bottom
Tender frame sills	centre, 13 ins.; sides, 10 ins.
Tender trucks, kind	equalizer
Tender wheels, dia.	34 ins.
Tender axles	5½ x 10 ins.
Water capacity	5,000 Imp. gals.
Coal	12 tons

A cursory inspection of both Figures 8 and 9 will show that the construction of these Mallet locomotives is decidedly different from the practice followed by United States roads that have added Mallets to their rolling stock. Principal among these points of difference are the arrangement of cylinders and the absence of leading and trailing wheels, placing all the weight on drivers and shortening the wheel base.

Boiler

The boiler used in this series of locomotives has been changed very materially from that used in the original experimental Mallet. In this newer design, a plain wagon-top, radially stayed boiler is used, this design being found preferable to the three-compartment type used experimentally.

The tube sheets, 20 feet 1½ inches apart, provide for flues of a normal length, in contradistinction to some recent United States designs, where tube lengths up to 24 feet are to be found. It is in every sense a plain barrel boiler of the extended wagon-top type, with the possible exception that the corners of the fire-box, both inside and outside, are greater than usual to increase the boiler rigidity, as lack of the latter is believed to be responsible for staybolt breakage in the end rows.

The feed-water heater and superheater chamber being eliminated, a superheater of the Vaughan-Horsey type is placed in the smoke-box, the arrangement of headers, etc., being noted in the elevation drawing, Figure 9. The injector check valve is located on the top centre line of the boiler, under the bell stand, and has three connections—one for the left and another for the right-hand injectors, and a third for connection with pipe or hose coupling for use in filling or blowing off the boiler.

Instead of placing both sand boxes on top of the boiler, as in the former design, one of them is located in the upper forward part of the smoke-box, feeders leading down on the inside of the smoke-box shell. The box is filled through a small door on the top.

The experimental locomotive had a double petticoat smoke stack. In the new design this has been eliminated and a single wide-flare stack introduced in its place.

Frame, Connections and Spring Rigging

The frames for each engine are one-piece steel castings, slabbed for the cylinder fit, and also for the front bumper and back foot-plate. The sections of both top and bottom rails of the frames

are $4\frac{1}{2}$ ins. wide by $4\frac{1}{2}$ ins. deep and $4\frac{1}{2}$ ins. wide by 3 ins. deep respectively.

The only feature of particular importance about the frames lies in the manner of connection between the front and rear engines. In the experimental locomotive a plain pin connection at the point of juncture of the two connecting castings served as the means of connection. This pin was in triple shear when pulling, but was relieved of all strain when pushing, by the design of the connecting designs being such as to have corresponding contact faces, taking up all thrust independently of the pin.

The new method of frame connection is clearly shown in Figure 10, a plan view of the immediate vicinity of the connection. Essentially, the connection is similar to that between engine and tender, a built-up plate drawbar, 9 feet 8 inches long, as shown in the illustration, being used. This connecting drawbar is pin-connected at the rear end of the cross-bracing castings, between the cylinders. The faces of the castings, where they come in close proximity to each other at the inner ends, have a curved surface, with a radius to the centre of the drawbar pin. A concaved casting with similar curved surfaces acts as a filler, permitting a rolling motion between the front and rear engines when rounding curves. That is to say, the intervening piece so adjusts itself as the engine takes a curve that its centre is always in a line joining the two drawbar centres. This arrangement maintains a close alignment between front and rear sections, eliminating all play.

The drawbar was so designed as regards length that as the adjacent ends of the frames move outward when taking a curve, the centre of the drawbar is always in the centre line of movement, i.e., directly over the centre of the track, keeping the push or pull where desired, and overcoming the difficulties that would be experienced from side thrusts were the connections as in the original design.

Centering rods, to maintain the relative location of front and rear engines with regard to each other, are attached, one on each side of the connecting casting of the rear engine, these being attached by pins at the centre to the connecting casting of the front engine. as shown in Figure 10. The relative positions being thus maintained, the intervening distance casting has no tendency to jam in place.

When pulling, the front part of the forward engine of a Mallet has a tendency to lift, this condition being reversed when the engine is pushing. In this new design this undesirable feature is taken care of by means of bolts carrying compression springs passing down from lugs on the upper surface of the connecting casting of the back truck to similar lugs on the lower surface of the connecting casting of the front truck as indicated both in Figures 9 and 10. Thus, the connecting casting of the rear frame, through its bolts, carries the rear end of the forward frame when the front of the latter tends to rise, with a consequent depression of the rear end. The springs, mounted on the carrying bolts, absorb any quick fluctuations that may occur.

The spring rigging is of the usual type, equalized from front to

rear on each truck The forward engine has a cross equalizer at the front, but the rear engine is merely equalized along the sides.

Cylinders and Motion Work

Both pairs of cylinders are of the piston valve type, with inside admission on the high, and outside on the low pressure engines. They are decidedly unique, forming a radical departure from the

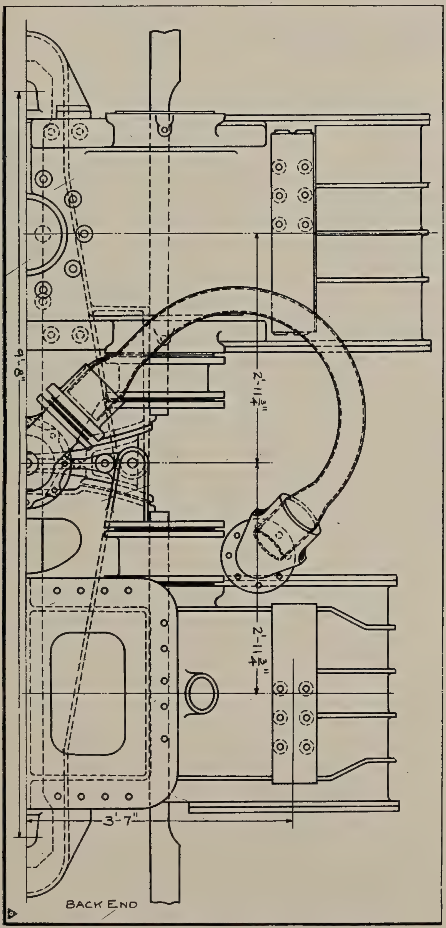

FIG. 10—Steam Piping on New Mallet.

practice heretofore followed in Canada. The low pressure cylinder being typical of both, is shown in Figure 11.

The point of particular change lies in the fact that the cylinders are made of cast steel, lined with cast-iron bushings. Making them of steel saves a weight of no less than 6,000 pounds, which is a very

important factor where weight elimination to obtain greater steaming capacity is desired. An examination will show how extremely light in construction the cylinder is, the shell being only five-eighth inch in thickness, with a corresponding high pressure thickness.

The cylinders are cast separately, divided in the centre line as usual. In the case of the high-pressure cylinder, there is a cast-steel saddle common to both cylinders and bolted to their top face, and to which the boiler is attached. The original low pressure had a small saddle bolted to the upper surface with a corresponding

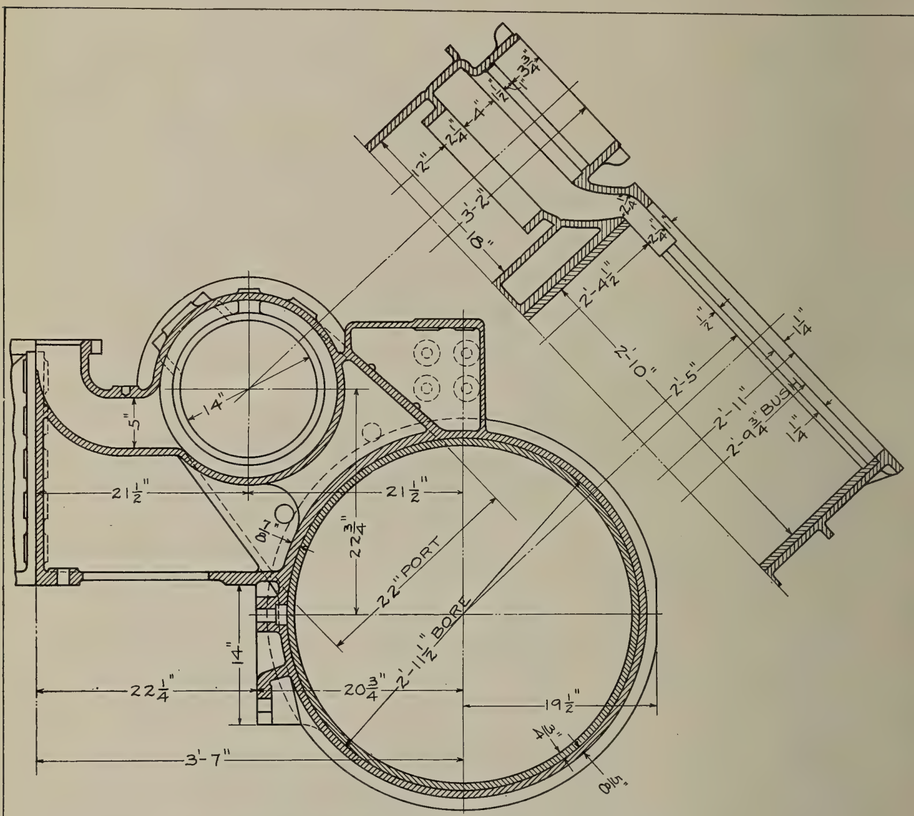

FIG. 11—Steel Cylinders of New Mallet.

saddle attached to the boiler barrel, bearing upon it. In this design this support has been dispensed with, for, on account of the movement possible at this point, pounding occurred, which could be attributed directly to the bearing surfaces knocking.

The Walschaert valve motion is used on both engines, and is of the usual type to conform to Canadian Pacific Railway standard practice with inside supported trunnioned bearings dispensing with encompassing support. The front radius rod has a long suspension

from the reach rod bell-crank, which, combined with a ball and universal joint at the lower and upper ends respectively, allows the engine to take curves without much distortion to the valve motion. When rounding a sharp curve, the boiler will swing about 9 inches off the centre line. This necessitates flexible joints. In addition, if the lifting link were short, it would swing over a considerable angle when on this 9-inch offset, resulting in a lifting of the radius link from its normal position. This would shorten the valve travel when in forward gear, and lengthen it when in backward. The length of link here shown is sufficient to make this feature practically negligible.

Provision has been made for changing piston packing rings

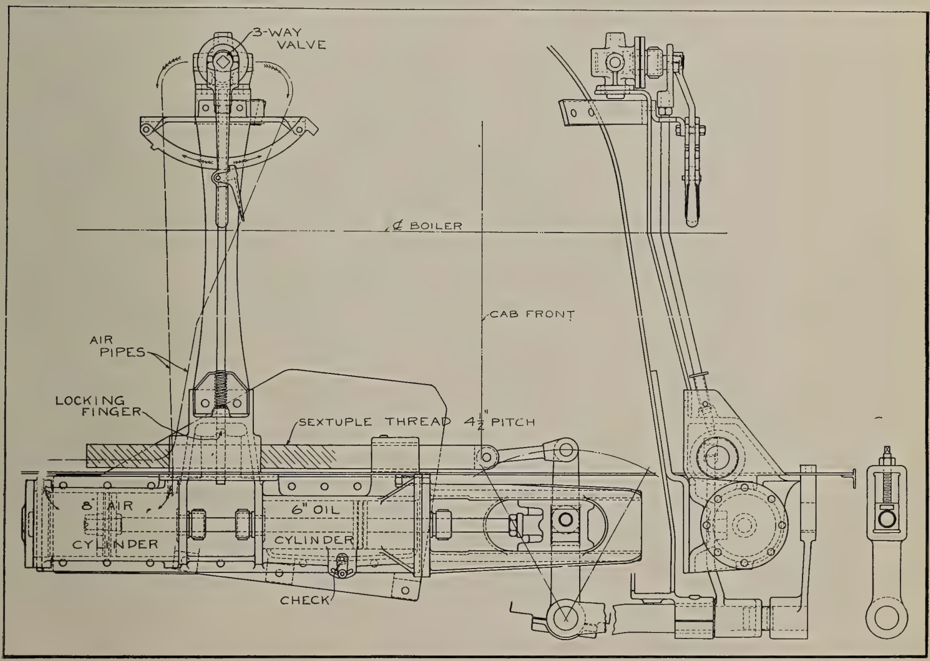

FIG. 12—Power Reverse Gear of New Mallet.

by simply removing the front cylinder heads, disconnecting the main rod from the cross head and pushing the piston out into the space between the two cylinders. The piston valves have also been taken care of in a similar manner, so there can be no objection in this arrangement of cylinders on the score of inaccessibility.

An ingenious mechanical reverse mechanism, shown in Figure 12, has been designed for this engine. The operating mechanism consists of an 8-inch air cylinder, dampened in its movements by a 6-inch oil cylinder with an adjustable by-pass connecting the cylinder ends. The crosshead of the machine is attached to a fulcrumed lever, the upper end of which is connected by a short link to a rod,

threaded for about two-thirds its length with a sextuple thread, 4½-inch pitch. This threaded rod is guided, in bearings attached to the top of the air and oil cylinders.

Confined in the casting above the opening between the air and oil cylinders there is a nut fitting the sextuple threaded rod. The outer surface of this nut is notched to receive a dog from above. This dog is moved automatically by the engineer when shifting the gear by the air valve above.

The operation is as follows: Swinging the handle of the 3-way valve to the right from the notch on the quadrant, lets air into the left end of the cylinder. The same movement of the 3-way handle raises the dog which engages the sextuple-threaded nut. This is performed by a projection on the side of the handle near its point of suspension, engaging another projection on the dog rod. Otherwise, the piston would not move by the air pressure, the dog engaged in the nut locking the piston in place.

The air moves the piston to the right, carrying forward the cross-head and lowering the links. The forward movement of the piston draws forward the sextuple-threaded rod, causing the nut to revolve in its retaining casting. When the gear has moved to the desired location, the 3-way valve handle is brought back to its vertical position, which drops the dog back into the nut, locking the mechanism instantly in the desired location.

The mechanism is so designed as to make it possible to change the amount of motion of the low pressure gear, without disturbing that on the high pressure cylinder. The high pressure gear receives its motion directly from the fulcrumed lever moved by the air piston. On the same shaft as this fulcrumed lever there is keyed another lever, shown at the extreme right in Figure 12. This lever has a block adjustable a couple of inches by a set screw. To a pin in this moveable block the low pressure gear reach rod is attached. As shown in Figure 9, this reach rod, being too long for one piece, is made in three sections, with the middle section guided in bearings under the runboard near the centre of the locomotive.

Piping

A standard throttle valve located in the steam dome of the boiler supplies steam to a long dry pipe which runs forward to the front tube sheet. Here it connects to the saturated steam header, and after traversing the superheater tubes to the superheated steam header, branches out each side of the smoke-box, to a lagged pipe under each runboard, leading back to the high pressure cylinder.

The piping for carrying the exhaust from the header between the two high pressure cylinders to the low pressure cylinder header is quite ingenious. This piping is shown to the best advantage in Figure 10, which, in conjunction with Figure 9, clearly outlines the arrangement. The idea was to pipe the steam from the high pressure engine to some point on the low pressure engine that had no motion relative to the latter. Such a point exists directly over the point of connection between the two connecting castings. This

was absolutely the case in the old design where a pin connection was employed. By bringing the exhaust pipe to meet the intake pipe of the low pressure directly over the pin-connected point, there is no motion between the two other than a slight circular one, allowed for by a swivel joint. In this new design, as the locomotive takes a curve, the new drawbar arrangement causes these central joints on both frames, to part as they swing outward due to the engine negotiating the curve. That is to say, the actual centre line of the locomotive lengthens—a case of two sides of a triangle being greater than the third.

The method of making these steam connections is as follows: The steam pipe, rigidly connected to the header of the high-pressure cylinder, is bent into a large loop as in Figure 10, the section of the pipe itself being first flattened into an oval section as indicated in Figure 10, the pipe thus assuming the shape of the tube of a Bourdon gauge. The other end is connected by a swivel joint to the low pressure header. Now, as the locomotive takes a curve, this central point of the swivel joint becomes further away from the corresponding point in the high pressure frame, by a fraction of an inch, causing the distance between the pipe connection centres to slightly increase. A solid pipe connection would likely break under such a strain, but having this pipe not only flattened, but also bent to a large loop, it contains sufficient flexibility to spring the necessary amount.

From the low pressure header, the steam passes through the cylinders and out through another swivel joint to the exhaust pipe. This contains another feature peculiarly different from standard Mallet practice, though similar to that of the experimental locomotive. The small side swing of the exhaust outlet of the low pressure cylinders (less here than even in the experimental locomotive, on account of the outlet being on top less than 3 feet from the point of swing), results in the elongation of this pipe being practically negligible. Thus the expansion joints in the usual design, capable of providing for extensions up to 1½ inches, are not necessary. Instead, the extension is compensated for by the sliding of the pipe flanges on the flat faces of the ball rings. The flanges are held in their seats by 10 springs of 200 pounds capacity each, or a total of 2,000 pounds. The exhaust from this point proceeds up the exhaust pipe.

Guiding Power of Front Engine

Guiding trucks have been dispensed with in this design of Mallet, it being believed that equally good guiding qualities may be obtained without their use. Their elimination reduces the wheel base and total weight, and the flange pressure is sufficiently low to safely warrant their absence.

In curving, it is the boiler body that offers the greatest resistance, and as the truck must swing laterally beneath it, it is supported partly by friction plates and partly by a spring suspended roller. The arrangement of these suspending means is clearly shown in Figure 13. As indicated, there are two main castings, one mounted

rigidly on the frames and the other bolted securely to the boiler body. One half the weight of the boiler is carried on plain, flat friction plates attached to the faces of the two main castings. There are four of these, in pairs, the intervening space being occupied by the floating device. The friction plates have ample surface, and are

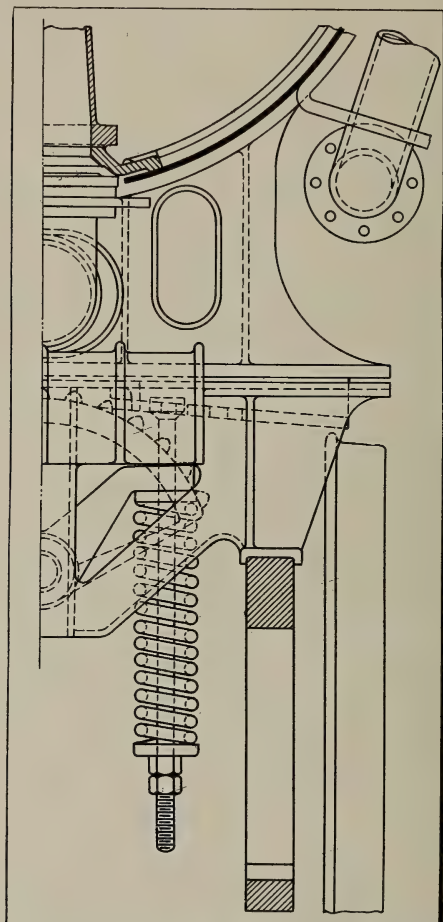

FIG. 13—Guiding Mechanism of New Mallet

provided with oil grooves across the surfaces, which, connected with an oil box in the upper castings, ensures ample lubrication.

In the intervening space mentioned above, the floating device is located. Two wedge-shaped pieces, as indicated, are secured to the lower face of the upper casting, one on each side of the centre. These wedges have two different slopes, the steeper one being at the centre. A toothed roller engages with similar tooth cavities in the

lower side of the wedge plates, this in turn being mounted on a floating shaft carried by two cross equalizers to springs supported on bolts from the lower casting. Any side movement of truck as when the locomotive is taking a curve, causes the inclined surfaces to force the roller downward against the resistance of the supporting springs, which produces a force to pull the roller around the curve with the truck, and relieve the rear truck, to which the boiler is rigidly connected, from much of the strain, that would otherwise fall on the flanges of the leading pair of drivers of the back truck. The greater the side movement of the truck, the greater will be the reaction from the spring compression, resulting in a constantly increasing rolling resistance.

The frictional resistance of the flat friction plates decreases on taking curves, for, on account of the depression of the floating springs, a greater weight is carried by the latter part of the supporting mechanism, relieving the friction plates of a portion of their load, thereby decreasing the frictional resistance. The intensity of the assistance offered by the floating mechanism to the pulling of the front part of the boiler around a curve with the truck, may be varied at will by adjusting the compression of the spring by means of the supporting nuts.

In conclusion, it might be mentioned that Mallet locomotives are giving the greatest satisfaction wherever they have been employed. From a traffic standpoint, they are all that could be desired, as the foregoing remarks concerning both the roads in the United States and the Canadian Pacific Railway will have emphasized. Mechanically, they have proved themselves superior to locomotives of standard designs. Notwithstanding the fact that there are a great many joints, etc., the machine efficiency is higher than on older types. Viewed thermodynamically, the efficiency is also high, for both the principals of compounding and superheating are embodied without the objectionable complications met with in the use of cross compounds. The only question that now seems to exist in the minds of those responsible for these new machines, is the factor of maintenance after the locomotives have been in service a number of years and are approaching the age of decrepitude common to all machines. Opponents of this type contend that the multiplicity of parts will lead to a rapid deterioration. But as they have been in service such a short time, no definite data has been collected on that point. Present conditions being satisfactory, it remains for the future to develop their weaknesses.

[*Note.—Many of the illustrations used in this article appear by courtesy of "The Railway and Marine World," Toronto.*—Ed.]

CITY PLANNING*

John M. Lyle

While the City Planning movement has been making rapid strides in Europe, in Canada, as yet, practically nothing has been accomplished in the way of comprehensive city planning. There are many signs, however, that at last the general public is being awakened to the great importance of this movement, and it is to be hoped that in the very near future all our cities, towns and villages will be replanned, and the new town sites intelligently laid out with a due regard to their future expansion.

It has been the custom of the past to have our cities and villages laid out by engineers and not by architects. This is, it seems to me, a very grievous error, and one that should be corrected if we wish to have our cities planned to advantage. A collaboration of the architect and engineer would give much better results; the architect's province being the general plan, the laying out of boulevards, squares, parks, etc., the studying of the problem from the point of view of circulation, transportation, parkway arrangement, the placing of public buildings, consideration of vistas, in short, the general scheme. The engineer should collaborate with the architect in the laying out of sewers, water mains, the working out of grades, the survey work, etc. The problem presented is essentially one of plan and, therefore, within the scope of the architect, who should, by his training, be better fitted for such a task, than a man who has had practically no training to fit him for the work that he is undertaking. If, in addition to the city engineers employed throughout Canada, the cities employed consulting architects on city planning, the results would, probably, be different.

Let us consider for a moment what are the principal points to be considered in the planning of a city. We might divide them roughly into the following:

1st. Circulation (streets, boulevards).
2nd. Transportation (surface cars, tubes).
3rd. Sewerage and water supply.
4th. Parks and parkway arrangements (monuments).
5th. Suburban lands.
6th. Markets.
7th. Water frontage.
8th. Slums, playgrounds.

Circulation

One would naturally suppose that when our cities were being planned, those responsible would consider the lay of the land, and make provision for not only a vertical and a horizontal circulation, but also for a diagonal circulation, and, possibly, a circular or belt circulation. On the contrary, we find an absolute lack of any consideration of the first principles of planning. The streets are

*Read before the University of Toronto Architectural Club, January 29th, 1912.

laid out at right angles to each other. There are many blind streets, and the main arteries are, as a rule, no wider than the ordinary streets. That this type of city planning is stupid, uninteresting and impracticable to a degree, needs no demonstration. In order that the citizen can go from one section of the city to another with despatch it is necessary that not only should the streets run at right angles to each other but that there should be wide arteries provided to run diagonally from focal points of importance, and also circular arteries, linking up other points. Boulevards, possibly connecting park systems, should be provided of a greater width for pleasure driving and walking. There is a divided opinion among city planners as to the best width to make these different kinds of streets. For the purposes of this paper, we will designate the above mentioned as streets, thoroughfares and boulevards. The general concensus of opinion is that for residential streets the width should be 60 feet, for business thoroughfares 86 feet, and for boulevards 125 feet. It has been found a mistake to make a business street too wide. Eighty-six feet is suggested, as it would give ample clearance for two lines of street cars, a 20-foot roadway on either side, and a 12 foot 6 inch sidewalk on either side.

Transportation

We come next to the question of transportation—a very vital one at present for the citizens of Toronto.

In considering this question, we will concern ourselves only with the different public systems of transportation, leaving out the private vehicle. To bring this part of city planning before you clearly, let us look at the transportation problems of our own city.

Firstly—We have the steam railroads.

Secondly—The radial railroads.

Thirdly—The street car system.

Owing to the fact that the railroads do not grant commutation rates, there is very little suburban traffic on the steam roads; and, owing to the fact that our radial lines come only to the outskirts of the city, there is not the travel on these lines that there would be if they were brought into the heart of the city. There remains the great carrying medium—the much abused Toronto Street Railway. While we feel that the service given us could be improved, the street railway company is not altogether to blame. The city is so badly planned that unless proper arteries are provided and the same supplemented by a tube system, Toronto need not hope for any relief for years to come.

It is absolutely impossible to get a rapid transit service on surface lines. If we desire to maintain the open character of residential Toronto and give every home a little plot of land, it is necessary to have the tubes. I, for one, pray that we may never see the tenement system in Toronto. In the heart of every Britisher there is inborn a love of home, the desire for a little place that he may call his own. Is this instinct to be fostered or to be blunted?

Have you ever stopped to consider what rapid transit means to a community of this size? There is a limit to the distance one can go with comfort on a surface car—none of us are anxious to become daily strap holders for three-quarters or an hour's ride. It is not only disagreeable, but it is a great economic waste—a waste of time and energy, which should be conserved to ourselves for our pleasure or our work.

Sewerage and Water Supply

These are essentially problems for the engineer. In passing, however, I might say that as a layman, it has always seemed strange to me that our intake pipe is situated where it is. Currents from the Niagara River and from the eastern and western gaps must surely affect it. Would it not be wiser to have gone fifteen or twenty miles below the city to secure a pure supply? It might interest you to know that the city of Hamilton in 1853 went eleven miles for their water supply, and to-day, as ever since, you can drink it from the tap.

Parks, Parkways, Monuments

It is estimated that in Canada eleven per cent. of the deaths from all causes are due to tuberculosis. Large sums of money are yearly expended in establishing and maintaining hospitals for the treatment of those afflicted with the dread disease—consumption, and the kindred tubercular maladies. Many public spirited men give of their time and means to this worthy cause. Would not much money and many lives be saved if more thought were given to precautionary measures? Can we not recognize that the modern tendency of population is towards the great cities, and plan for numerous parks, and squares—the lungs of a community—*just as essential* to a city as the lungs are to the individual.

Toronto is very badly off for parks. There is really only one park which is worthy of the name and that is High Park. The main argument against having additional parks and playgrounds in Toronto is the great cost of procuring the land. This is a very real objection and can only be met by the city acquiring control of the planning of suburban lands, and by laying out these lands with the fixed idea that eventually they are to become a part of the greater city. Then it would be possible to provide in advance for ample park and playground accommodation. It is commonly remarked that Toronto covers a large area. Compared with the German cities—she is nowhere. The city of Dusseldorf, with 300,000 inhabitants, has an area of 29,000 acres; the city of Cologne, with a population of 428,700 has an area of 28,800 acres; Frankfort, with a population of 335,000 has an area of 23,203 acres; Toronto, with a population of 400,000 has an area of 16,320 acres; in other words, but little more than half what the same sized German city would have. The reason for the great area of the German cities is their large park and parkway areas—they are veritable garden cities.

Parkways

The parkway is a feature of city planning which is comparatively unknown on this side of the water, yet it has great value in the general scheme of city planning. A parkway, in contradistinction to a park—is a strip of sward placed to the side of a thoroughfare. This sward is planted with trees and shrubs, and laid out with attractive flower beds. Benches are provided, while statuary and fountains are placed at intervals. Bridle paths and walks flank the central sward. These parkways are sometimes two or three blocks long and sometimes several miles. They are a most attractive feature, and an especially valuable one in a residential section.

We might to advantage adopt this idea in Toronto—having in our Rosedale Ravines beautiful natural parkways capable of embellishment.

Monuments

If the parks and parkways are the lungs of our cities, may it not be said that the statues, architectural monuments and arches are the outward expression of the soul of our community? Do they not express the ideals, the aspirations, and the hopes of our citizens? How important they are, we little realize. How they inspire the youth with high ideals of patriotism and duty. A concrete example of just this inspiring quality of the monument is the new South African Memorial just erected at the foot of University Avenue. Mr. Allward's fine work changes the whole aspect of the neighborhood—it stands a mute protest against commercialism; it stirs the imagination to thoughts of empire, home and country. It reminds us that there are other men who are empire builders, beside the much advertised commercial magnates of the day. May we have more monuments of importance to point the path of honor, and to remind us that we also have other duties beside those of our immediate fireside.

Suburban Lands

One of the greatest obstacles to city planning in this country is the absence of any power of control by the municipalities in the planning of the suburban lands immediately adjoining the cities which are in process of urbanization. Until legislation is enacted enabling the municipalities to control the laying out of these lands, our cities will be planned by the real estate speculator and not by the city planner.

Markets

We are all aware that the cost of living is high, and that there are many reasons for it. Perhaps our shopkeepers need a little competition. It is generally understood that canals are necessary to regulate the freight rates, and to check any undue tendency on the part of the railroads to increase their dividends. Would it

not be a good idea if, instead of one central market, we had a dozen small attractive markets convenient to the housewife? We have neighborhood libraries and neighborhood banks—why not neighborhood markets?

Water Frontage

In Canada we imagine it is impossible to have our water fronts both useful and ornamental. Private interests have become so strongly entrenched that any suggestion of a change in policy is not given more than a passing thought. How different the attitude of other countries. Take for instance the water fronts of the German cities—such as Hamburg, Frankfort, Cologne, Dusseldorf, or the magnificent harbor and water front of Rio de Janeiro. Here we find the foreign architects planning their waterfronts with an eye not only to the utilitarian side of the problem, but also with keen regard for the aesthetic. Provision is made for various kinds of freight. Wide embankments are built with spur lines connecting with the main railway systems. Oftentimes four and five lines of railroad tracks are run out on the docks, and freight can be transferred directly from the ships to the cars. The docks are ample and provided with all the latest hoisting devices, both great and small. Large store houses with railroad connections are built. Everything possible is done to facilitate the handling of freight. Nor is the aesthetic side neglected. Wide boulevards are constructed along the water front, equipped with all the necessary facilities for the enjoyment of aquatic pleasures. Bathing pavilions, landing stages, and casinos are built.

In Germany, the water front belongs to the city, and that it pays to have a first-class municipal harbor equipment is certain. Take for example, the harbor development of Frankfort.

The city lies upon the River Main, which was not navigable for Rhine traffic. The city fathers borrowed eighteen million dollars and proceeded to deepen the River Main for several miles —they erected docks and handling devices. What was the result? Its harbor traffic increased one thousand two hundred per cent. in nine years' time. The first harbor became inadequate, and a far more elaborate programme has been entered on.

Slums—Playgrounds

Large cities mean congested areas of population. Congested areas mean slums; slums mean disease, degeneracy, crime and immorality. The product of the slum is an inferior citizen; inferior citizens mean an inferior race, and consequently an inferior nation. Hence the importance of adopting radical measures to forestall the growth of this canker of modern city life.

Does anyone doubt the baneful influence of the slum? Let him look at the besodden types of East London, or the dwellers in the poorer districts of any of the great European cities. Yes, and in any of the great cities of the New World. Let him go down to the lower East Side of New York and see the results of slum conditions.

As yet, in Toronto, we have only the beginnings in two or three districts of the slums of the future. These modest efforts, however, promise well for the future growth of "Slumdom." We already have many wretched hovels and cellars which house numbers of families, where sanitary conditions are set at naught, and where both sexes are herded together indiscriminately.

How is the slum to be fought? By eradicating one of the greatest evils in city life—overcrowding. By forcing the property owners to conform to a general scheme for the development of the whole community. By eliminating narrow streets; by enforcing certain regulations as to the number of families that shall occupy a given house. By restricting the height of a house. By providing playgrounds and parks within easy walking distance of every home. By enforcing the regulations that no more than a certain percentage of the land shall be built on. If these ordinances were carried out we would be safeguarded against the growth of slums in our midst. Especially would this be true if the last mentioned regulations were enforced.

In the German cities the regulations in regard to the area that can be built on are very stringent. Take for example the city of Cologne. Here we find that a prospective builder in the business section can only build on seventy-five per cent. of his land; in the second building area on sixty-five per cent.; in the third area on fifty per cent., and on the outskirts on only forty per cent. of his property. It will readily be seen that such regulations would make for the beauty, health, comfort and happiness of a community. It might be urged that in enforcing such strict regulations that the property owner was not being fairly treated. Experience has proven the contrary. If a neighborhood is protected by certain building restrictions, as a rule the property has a proportionately greater value.

Playgrounds

One of the greatest enemies to the slum is the public playground. It is well known by penologists that the criminal is made in his youth. It is also well known that the criminal product of the old world "slum"—the descendant of perhaps several generations of criminals—is one of the most difficult of men to reform. If the youths of our crowded districts have no place but the streets to play in, it does not take a vivid imagination to picture the evil results to both health and morals from such a condition of affairs. New York has recognized the importance of playgrounds for her congested districts. She has already laid out several squares fully equipped with shelter accommodation and with gymnastic appliances and space for open air games. She has also provided large recreation piers on both the North and East Rivers. These piers extend out into the river and are double decked as it were—roofed in above and open on the sides. It is, indeed a sight to see the crowd of mothers and children in one of these pavilions on a hot summer's afternoon.

In respect to playgrounds, Toronto is ill equipped. Would it not be possible for the city to create a series of playgrounds? They are sadly needed.

What Germany is Doing

From time to time I have had occasion to refer to Germany and different German cities. You will, perhaps, be interested in knowing what Germany is doing in the matter of City Planning.

Of late, we have all read much of Germany in the press, in books, and in magazines, and many are the speeches where the "German Bogey" has been pictured in glowing terms to a sympathetic audience. We have read of dreadnoughts until the word has become a positive nightmare. We have even a golf club called "The Dreadnought."

In all the discussions that have taken place but little attempt has been made to analyze the reason for the great progress that Germany has made in the immediate past, and is making to-day. Could we not learn some lessons from this enterprising, aggressive people?

If we were asked, what more than anything else had contributed to Germany's greatness, the answer would probably be "education" and "legislative foresight." Germany more than any other country has recognized the importance of looking ahead to the welfare of her future citizens, and by wise legislation is solving one of the greatest problems of the day—the planning of the city. Her farseeing statesmen have realized that modern life has changed the conditions under which great masses of her people live. They have seen that great numbers are gathering together in large centres; that the cities have grown at the expense, oftentimes, of the country, and they realize that great cities have brought consequent evils; slums have grown up, crowded districts have become a menace to the health and morals of the nation. They have found that the old haphazard planning and the old method of handling civic problems have produced results which are affecting the well being of the whole nation, the health and happiness of her people. She has realized that unless her citizens are strong and healthy, it would be useless to have a large army or to build huge dreadnoughts, if she did not have the right men to form her battalions or to man her ships.

Germany has, therefore, undertaken to enact legislation making for the proper laying out of her great cities to a general plan, having in view such arrangements for transportation, parks, parkway system, location of schools, fire-halls, as would give to future generations the advantages of a well ordered community.

Is this not surely a *great imperial idea?* Could we not in the British Empire awaken to the needs of such legislation? Contrast the large German cities like Berlin, Munich, Dresden, Dusseldorf, Mannheim, Frankfort, Cologne, Weisbaden and Stuttgart with the cities of this country, or in fact, of any other country. What do we see? On the one hand, we have the Germans attacking the problem in a scientific and rational manner; expert architects plan

their cities, expert engineers lay out their sewers and grades, experts in hygiene report as to conditions affecting this branch of civic work —and on the other hand we have nothing but bungling and haphazard planning.

They are not only considering the people of to-day, they are thinking of future generations; they are studying the problem of City Planning as they are studying the problem of their army, their navy, their mercantile marine, or their manufacturing interests.

Private interests are not allowed to dictate terms to the detriment of the whole community. Water rights are preserved for the benefit of the people. The speculative builder is restrained. In short, the problem of city planning and city government is treated as a business proposition, and order and control are evolved out of chaos and uncertainty.

The plans are prepared on the most complete and elaborate scale, having in view the growth of the city. Streets, boulevards, parkways, school houses are laid out far beyond the city limits, sometimes to a distance of thirty miles.

We would study to advantage the policy of land ownership as adopted by the German cities. The result of this land ownership is that the German cities are enabled to finance their schemes for civic improvement; they can control the surrounding territory which is in process of urbanization.

It has been so successful that there are 1,500 small towns in Germany where the revenue derived is so great that there are no local taxes whatsoever. There are five hundred of these towns where not only are there no taxes but a dividend of from $25.00 to $100.00 per year is paid to each citizen as his share in the earnings of the common lands.

The Importance of a Fixed Policy in Regard to City Planning

Time has wrought many changes in France since Baron Haussman inaugurated under Napoleon III his scheme for the rebuilding of Paris. The form of government has changed from monarchy to republic; mayors and city councils have succeeded each other, but despite the many changes in administration, we find the same policy of replanning being steadily carried out after the original scheme, as planned by Baron Haussman in 1853.

Washington is another example of many where a city is being developed along the lines of a well considered and comprehensive plan made by the great architect L'Enfant in 1791.

We know that London, Paris, Berlin, Rome, Washington, New York, Cleveland, Rochester, Kansas City, Frankfort, Cologne Dusseldorf, Genoa and many other of the great cities of the world are replanning their cities, and are providing in an intelligent manner for the future growth of their different communities.

While it is true that Germany is leading in the art of city planning, it must not be forgotten that England also is awakening to the importance of the well planned city. Especially in the development of garden or model suburban towns is England making progress,

the two garden towns of Port Sunlight and Bournville being laid out in the most intelligent and attractive manner—the work of two English architects. London is spending millions of pounds in cutting through avenues and streets; she is doing to-day what was advocated by one of the fathers of city planning—Sir Christopher Wren—the famous architect, just 246 years ago. No better illustration could be found of the stupidity of a people in not recognizing the self-evident advantages of a well planned city. It is probably costing the city of London as much to-day to cut through one little street as it would have to lay out the whole scheme as planned by Wren in 1666. It will surely interest many to hear something of Wren's plan for the rebuilding of London after the Great Fire; if his scheme had been carried out, London would have become the wonder of the world.

Sir Christopher Wren was commissioned by King Charles II to prepare a plan for the rebuilding of the city of London. He proposed to widen the streets, to create two large circles with radiating streets and connecting avenues, to form public places into large plazas; to unite the halls of the twelve chief companies into one regular square annexed to Guild Hall; to make a commodious quay on the whole bank of the river from Blackfriars to the Tower. The streets were to be of three magnitudes—the principal streets running through the city to be 90 feet wide, the secondary streets 60 feet, and the lanes 30 feet wide.

The Exchange was to stand free in the middle of a plaza, and to be, as it were, the centre of the town, from which the 60 foot streets should radiate to all the principal parts of the city. Many streets were also to radiate upon the bridge. The streets of the first and second magnitude to be carried as straight as possible and to centre into four or five plazas. The quay or open wharf on the bank of the Thames to be spacious, and provided with ample warehouse and docking facilities. He proposed to rebuild the parish churches in such a manner as to permit of them being seen at the end of every vista. He further proposed that a wide avenue be constructed from Oldgate to Temple Bar in the middle of which was to have been a large square capable of containing the new Cathedral of St. Paul's —the Square to be large enough to afford a view of the building from all points. What a comparison between the splendid square and the cooped-in aspect of this magnificent church of to-day.

Should we not profit by London's example and take to heart her lesson for ourselves? Does it pay to spend money on the beautifying of a city? Most emphatically "yes." Take away from any of the European cities their beautiful monuments, parks and avenues, and where would the millions of tourist money come from? Make Toronto not only a healthy city but a beautiful one and the money from abroad will pour into the coffers of the merchants of King and Yonge Streets.

Should we not remember that a beautiful and well planned city is not only a source of pride to its citizens, but a great factor in the upbuilding of the empire—a power for good in the world, one that makes for the prosperity, health and happiness of millions of human beings.

POINTS CONCERNING PRODUCER PLANTS

By C. F. Publow, B.A. Sc.

[*The following article, descriptive of producer plant installation and operation, contains a valuable amount of detail not ordinarily found in writing. An attempt has been made to enumerate numerous small and lesser important points that constantly arise. They are often omitted as superfluous to the reader well informed in power house operation. There is a tendency to overlook the need of the undergraduate and his inferior knowledge of practical points. The aim of the writer of this article has been to supply information that will lend itself to easy assimilation on the part of the student, referring frequently to the particular installation of which he is in charge.*—Ed.]

The engine and producer plant which has been installed in Davidson was manufactured by Daniels, Strand, Eng., and it consists of a producer lined with fire brick, and its vaporizer; a water heater, for the water flowing into the vaporizer; a hydraulic box or washer; a scrubber filled with coke and having a spray of water entering at the top and running out at the bottom; an expansion box containing a quantity of excelsior; and lastly, an engine of the four cycle type, with throttling governors. This engine is specially designed for electric lighting work. Its frame weighs approximately three tons, exhibiting a marked difference between steam and gas engine practice for the same power (36 b.h.p.). Its flywheel is 7 ft. 8 ins. in diameter, with a 12-inch face, and weighs approximately three and one-half tons, showing what an extremely heavy wheel is required to give a constant angular velocity of itself due to only one working stroke in four. The speed of the engine is 220 r.p.m. It is belted to a 30 K.V.A. 3-phase Westinghouse alternator, 60 cycles. This in turn is belted to a 2-K.W. Westinghouse exciter.

As is the case with any plant, the object of a producer plant and engine is to convert the heat energy due to the combustion of a fuel (anthracite coal in this case), into mechanical energy. In their methods of accomplishing this, engines divide into two classes: (1) *external* combustion engines, the steam engine being a well known example, where we have complete combusiton of fuel entirely separate from the engine, and use a working fluid; and (2) *internal* combustion engines, gas and gasoline being examples, where part at least of the whole combustion occurs inside the cylinder, and thus acts directly to drive the piston. The producer plant and engine belong to the second class. Partial combustion occurs in the producer, where the fuel is transformed into gas, and this gas is led through the scrubbers to the cylinder, where the combustion is completed, supplying the energy in mechanical form. It is in the direct conversion of heat energy to mechanical energy that this type of engine finds its great fuel economy.

Producer plants are divided into two groups, to which the terms "pressure" and "suction" are applied, "pressure" where the air required for the generation of the gas is delivered to the gas producer under pressure derived from an auxiliary source, the gas generated

being then delivered to the engine under the same pressure; "suction" where the suction stroke of the engine causes the draft which generates the gas. The plant in Davidson is of the latter type.

A few outstanding points regarding this type, and applying in part to all internal combustion engines, are worthy of note:

(1) The conversion of heat energy into mechanical energy directly in the cylinder as previously mentioned.

(2) Little water is required to operate it.

(3) There is no danger of explosion, the gas being generated only as required.

(4) There is no occasion for any more specially skilled labor to operate than in the case of the steam engine.

(5) The space per h. p. is relatively small, including the whole plant equipment.

(6) In fuel it is extremely economical.

(7) In the matter of starting, the time required is short. On several occasions we have had this plant in operation within five minutes after starting to blow the fan.

(8) Small consumption of fuel is required during standby.

It will be seen from the above that these conditions comply favorably with the demands of Western Canada. Fuel is expensive, and water scarce in many places. Skilled operators are hard to secure and wages are high.

Erection

In the erection of our plant concrete was used for the foundation throughout. Special care was taken in proportioning the mixture used, this being considered as demanding more attention than ordinary cases.

Regarding the placing of the foundation bolts for the engine, it was decided they should go down to at least within one foot of the bottom, the depth of foundation being governed by nature of soil and heaviness of engine. Care must be taken that they are left sufficiently high as they can be cut off after the engine is in place. They should be placed with great precision and checked well. To compensate for any slight error due to displacement while filling in, they are placed in pipes that are ½-inch larger in diameter than the bolts. It is good practice to get the whole foundation constructed in a short lapse of time so that the whole will set simultaneously..

After the frame is placed on the foundation leveling must be looked after. Iron wedges were used for the purpose in this particular plant. The type of engine has two shafts, both horizontal, one at right angles to the other. The cylinder must be slightly inclined towards the crank shaft, otherwise the lubricating oil is liable to accumulate in the combustion chamber and cause trouble. A good practical test for levelness of crank shaft is that when the bearings are tightened down, the shaft turns free and drops of its own weight. At this juncture care must be taken in tightening the frame into position as there is a liability to strain it. This might easily throw the main bearings out and cause trouble. Also, in

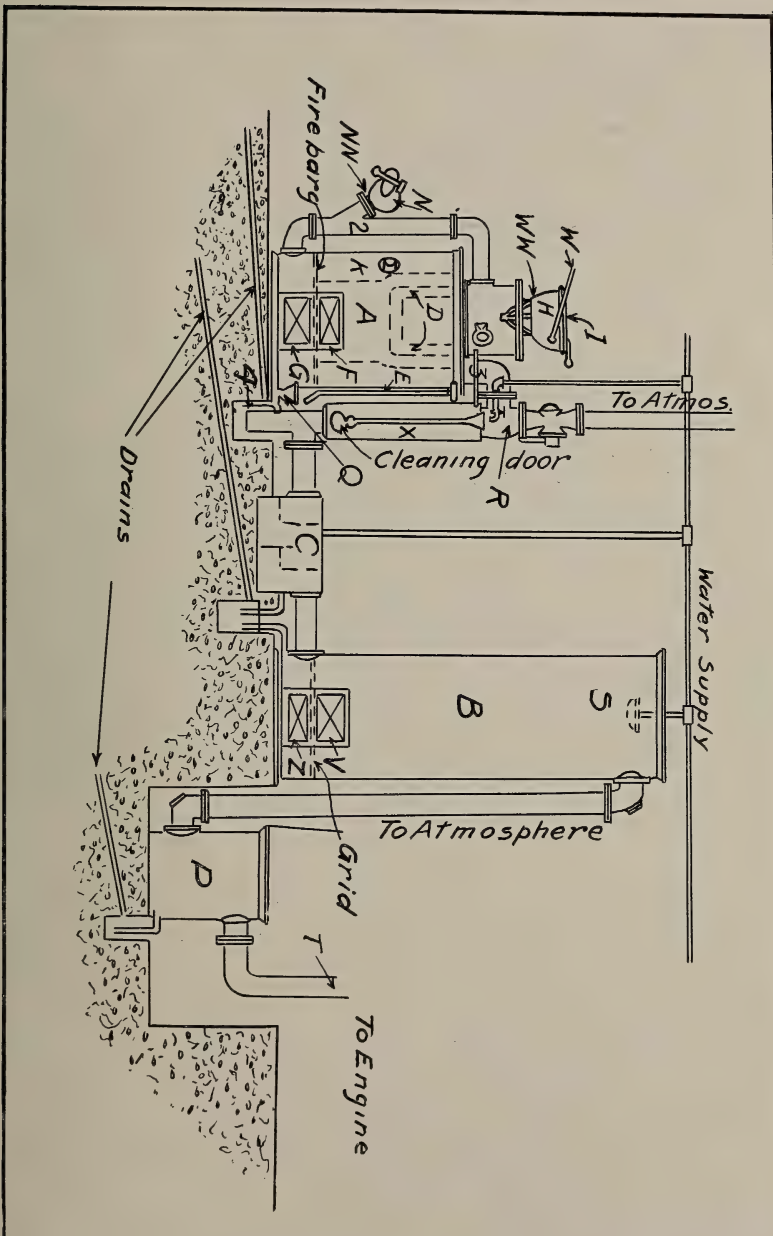

FIG. 1—PRODUCER DETAILS.

A—Producer. F—Fire door. G—Ashpit door. D—Vaporizer. H—Hopper. I—Hopper lid. W—Lever. WW—Valve in hopper. K—Air supply pipe. 2—Pipe to convey saturated from vaporizer to below the grate. L—Air supply valve to vaporizer. 3—Vaporizer feed water pipe. E—Vaporizer overflow pipe. N—Fan. NN—Fan valve. Q—Opening to supply ashpans with water. 4—Ashpit drain pipe. C—Hydraulic box. B—Scrubber. S—Water spray. P—Expansion box. R—Test cock at producer. T—Test cock at engine. X—Heater

placing the cam shaft in position the proper cogs must mesh, otherwise the timing of cams and spark will be wrong. The engine is water-cooled by the thermo-syphon or gravity systems. Care was taken to have circulation as free as possible and to this end sharp angles in the hot water pipes were guarded against, and a gentle rise from bend above the engine to the tanks aimed at. Since hot water is lighter than cold, it follows that the higher these cooling tanks are above the level of the cylinder the better the circulation. The hot water flows in at the top, and the cooling water leaves from the bottom. Where there is a number of tanks the hot and cold water should be kept as far apart as possible. The tanks may be connected either in series or parallel. This cooling system requires but little water, and for small sizes of engines is very efficient. Valves are inserted to control the circulation and to permit the draining of the cylinder, during cold weather, if found necessary. To aid in draining, an air vent is also put in to prevent air locking. It also serves to prevent air locking during ordinary starting up and shutting down each day. Care must be used in seeing that the water in the tanks is well above hot water outlet, otherwise circulation is interfered with, and, perhaps, entirely stopped.

Engine Connections

In connecting up the gas plant to the engine, cast pipes were used. This required starting from the engine and working back to the producer, temporarily blocking each part in its place, so as to allow for any alterations which might later be desired. Care was taken not to use wooden blocks in places where there was a likelihood of any excessive heat, as the blocks are grouted in when the foundations are built.

Hydraulic Box and Seal Pots

When erecting the hydraulic box see that the overflow pipe is set to keep the water at the proper level in the two parts so that gas will bubble through constantly. If the overflow is too high the water will seal it for a time, and then the gas will "rush." The result is that it will be unsteady and poorly washed. Again, if the pipe be too low the gas will not be thoroughly washed or cooled. These conditions effect the operation of the engine very seriously.

With regard to the placing of seal pots, attention must be given to insure the required fall, otherwise the suction of the engine will "hold up" the water and soon flood the parts sealed, causing a great amount of trouble. Mention of this feature will be made later.

Starting the Producer

In starting a fire in the producer, oily waste and kindling wood, followed by a careful application of small quantities of coal, produce quick and effective heat, the fan being in operation before coal is supplied. An even layer of burning fuel upon the grate is desired, otherwise the entire effective heating surface will not be utilized,

and the unburnt air which would leak through the dead coal will deteriorate the quality of the gas produced. A bed of live coal, three or four inches thick prepares the producer for additions of fuel in large quantities. The producer on the Davidson plant has a capacity of approximately 150 pounds fuel, but the engine requires a much smaller quantity for beginning operations.

To get gas either from new fire or standby, the slides are closed so that air from the fan is forced under the grate and up through the fire. Also, there must be water in the ash pan under the grate. This produces steam for the gas, enriching it.

At first the gas is poor and is allowed to escape directly to the atmosphere from the producer. A test cock is placed upon the producer to ensure a sufficiently good quality before beginning operations. When good gas is obtained (recognized by its violet-rose flame, its great heat, noiseless burning and no tendency to blow out) the atmosphere valve is closed, and the gas is forced through the rest of the plant.

Near the engine is a secondary test-cock which is lighted, in its turn. If the flame produced shows gas of desired quality, the atmosphere valve at the engine is closed and all is in readiness for starting. Now in the other parts we may have air, stagnant gas, or both, neither of which are useful. To eliminate them an atmospheric pipe is placed close to the engine, and through it these undesirable gases are blown.

While blowing up the fire to generate gas, the engine is put in readiness, by seeing that the spark is retarded, the cams arranged to give half compression, (i. e., the exhaust valve opens on the compression and exhaust strokes), the air valve set in starting position, which has to be found by experiment after the plant is erected; and as we start by compressed air, the engine must be placed on the expansion stroke just past the inner dead centre. At this setting all valves are closed, and the return stroke being exhaust, the cylinder frees itself. The compressed air tank is then opened and air applied to the piston. As the air is at approximately 100 pounds pressure, we can use its expansion qualities, thus saving air. To do this apply it during about half the stroke. After the engine has gone two revolutions it is again in the starting position, and air is again applied during the half stroke. By this time the engine has quite a considerable momentum, and by turning on the gas, it draws in a charge on its suction stroke. The explosion of this charge imparts the momentum. This tendency to "pick up" on half compression is a good indication of the proper mixture and spark setting. The engine is then placed on "full" compression and the spark gradually advanced until the engine attains its working speed. Once the engine starts, the fan is shut down and the slides opened so as to allow the proper suction, with which to make its own gas. We have found it a good practice to get the engine up to "speed" as quickly as possible so as to give it a large momentum. Then, if there happens to be any failure in the gas supply, it will have enough momentum to draw sufficiently on the plant to make its own gas,

and not slow down. Once explosions cease in a case like this, it indicates a failure of the gas, and to aid the engine we make the whole of the suction charge a draw on the plant by closing the air valve.

When the engine starts, washing water should be turned on in the hydraulic box, and in the scrubber.

Once the engine is running on its own gas the mixture requires adjusting from starting proportions. It is found that the engine-made gas cannot be lit at the test cocks, it being of a very much poorer quality than that obtained by blowing. An explanation of adjusting the mixture will be given when the governing device is under consideration.

Recharging Air Tank

When the engine is "away" on its own gas, it is time to recharge the air tank. Now the producer is in a very active gas-forming state, and as we only require air in the tank, the gas admission valve has to be closed and the atmosphere valve at the producer opened to allow part of the gas generated, while recharging the tank, to escape. Otherwise it would accumulate and explode, being hot and mixed with air. No particular damage occurs from these, but as they are easily prevented, it is best to do so.

To charge the air tank we use the compression stroke of the engine, and to aid in getting it done quickly we once more use a maximum admission valve opening. Care must be taken to allow no burnt gas into the tank as the heat from it ruins the springs in the valve arrangement by rusting them very quickly. When the tank is recharged, or the engine's speed gets low, we discontinue the operation. First, the air valve is closed and the gas valve opened to allow a few strokes on the gas alone, so as to draw off quickly any accumulated gas, preventing the explosions in the producer referred to above. Then the mixture is adjusted and the atmosphere valve at the producer closed. This recharging process must be repeated until the tank is full.

History of the Working Fluid

With the engine running, a brief history of the working fluid might not be out of place. Air is drawn in over the top of the vaporizer where it mixes with steam. From here it is drawn under the grate. In passing through the heated grate it first burns to CO_2 and later, being still in contact with red hot coal, it absorbs another atom of C forming CO, a combustible gas. The steam also passes up through the fire and is decomposed, the hydrogen remaining free and the oxygen uniting with the carbon to form carbon monoxide. The gas is now very hot, and contains many impurities, both gaseous and solid. It is now drawn to the top of the producer, giving up part of its heat to the vaporizer, where the steam is formed. It leaves the producer by passing downward through the heater, where it again loses heat (used to heat the water flowing into the vaporizer).

At this point a turn is made at right angles to the washer, where the largest solid matter is deposited into the seal pot. In the washer the gas makes two complete circuits. Required to bubble through water twice, it is washed and cooled. From here it enters the scrubber and passes upward through the coke, which absorbs the ammonia, sulphur, tars, etc. The scrubber water, in trickling down carries away these impurities, thus keeping the coke in working condition. From the scrubber the gas is drawn into the expansion box, which is close to the engine, where any moisture which it contains is deposited and collects at the bottom of the box, to be drained off every day. From here the engine draws the gas into the cylinder through the admission valve, together with air, the two mixing as they enter the clearance chamber. After the charge enters the mixture is compressed, fired, and after doing work during the expansion stroke, it is exhausted to the atmosphere, chiefly as CO_2 and H_2O. It must be remembered the nitrogen of the air has been present through the chemical changes in the cylinder, but, as it is inactive, it is left out of consideration.

Operation

In operating the producer should be kept full or nearly so, otherwise air is drawn in at the hopper, spoiling the quality of gas formed. Steam being a great clinker preventative, as much as possible is passed through the fire. To this end water is kept in the ash pan at all times so that we may obtain steam from radiation of the grate bars. If the load gets very heavy free air may be required to be admitted, so as not to deaden the fire with too much steam. Attention must be given to the condition of the grate bars, so as not to allow them to decrease in temperature, for then the fire rises in the producer, and is not sufficiently deep to cause all of the CO_2 to form CO. This seriously injures the gas. We must also maintain the coal in a solid mass, as clinker in the body of it along the fire brick allows the gas to pass quickly in large quantities, thus lowering its quality. These clinkers must be broken up and removed.

The vaporizer must never be allowed to become dry or it will burn out very quickly. It is best to have it on the point of overflow at all times. During operation water must be kept running through the washer in such quantities as to just allow it to become warm, and sufficient water is required by the scrubber to keep the coke clean.

Forced feed oiling is used on the cylinder and piston, it being injected at the top of the cylinder by means of an oil pump operated by a cam on the cam shaft. This cam is capable of adjustment and the question naturally arises, when is the best time for it to operate. The lubricating oil is burnt to a certain extent during the expansion stroke, and thus looses at least part of its lubicating qualities. Again, since it has the whole piston to lubricate and is forced in at only one point, it must be given as much time as possible to spread before the explosion. The best time to pump oil in is evidently

at the beginning of the exhaust stroke. This allows the oil to be spread all along the top of the piston, and gives it the time required for the admission and compression strokes in which to spread before the explosion occurs and decreases its efficiency by burning.

It must always be remembered while operating that as much work as possible should be obtained from a quantity of coal. This implies that the quantity of gas used must be made to do a maximum amount of work. To obtain the maximum efficiency of the gas requires just the required amount of air to get an explosive mixture, such that, under the conditions in the cylinder, it will do the work necessary without consuming extra gas, thus causing the smallest draw on the plant.

Again, to have the engine, with a working stroke in every four, exert a more uniform torque, will mean more uniform speed and smaller impulses. To obtain this we require the same charge in each suction stroke, *i. e.*, the same admission valve opening, which necessitates the same pulsation of the throttle governor.

On the particular engine to which we have so frequently referred in this article there is an adjustable spark, with positions ranging from starting at 5° late to running at 46° early. Thus, with the spark set in running position (advancing the spark has the same effect as making the mixture richer, providing it is "lean," and that is a higher compression pressure and thus greater expansion), we can adjust the air valve so as to give a mixture which will maintain a steady speed, and take in the same size of charge on each suction stroke.

Difficulties and Remedies

The best time to build in the fire brick lining of the producer is after it is erected, using just sufficient thin fire clay to make them air tight. If built in earlier there is a great danger of the bricks becoming cracked and the fire clay broken. This can be overcome to a great extent by pointing them up or better grouting them in, just before setting up.

The particular coal in use requires its own method for handling the clinker, as quality of coals differ greatly. We have found that a large quantity of steam is required to keep the fire cool enough to prevent the formation of clinkers. Again steam is very helpful in allowing the ash to clinker, but not harden, which admits of easy removal. To clinker well we allow three to four inches of ash to collect on the grate, taking care not to let it set until just before drawing, otherwise all the draft would go up through fire in just a few places, a very undesirable condition. As the plant is relatively small, only a small amount of gas is on hand, and the clinkering must be done quickly, leaving the door open only a short time. When slicing the grate bars to free them from small clinkers and ash, if there is plenty of water in the ash pan, the red hot coals falling through causes a good quantity of steam to be formed to keep up the quality of the gas.

On erecting our scrubber the seal pots were set too high, causing some trouble. The suction of the engine was sufficient to "hold"

water in the scrubber with the drop it then had. Thus the space below the coke grate flooded. Under these conditions, on the suction stroke of the engine, the whole body of the coke was lifted, causing a rumbling noise. This lifting and falling of the coke broke it up and caused it to fall through the grate and into the seal pot, choking it up. Upon closing the gas valve the suction on plant ceased, and all the water in the scrubber came out, overflowing the seal pot. This was remedied by placing the seal pot from 6 in. to 12 in. below the bottom of the scrubber.

The easiest way to test if the valves are seating properly is to try the engine for forward and back compression both at "full" and "half" and at the same time to notice the running of the engine, assuring oneself of the condition of bearings, piston and rings. If

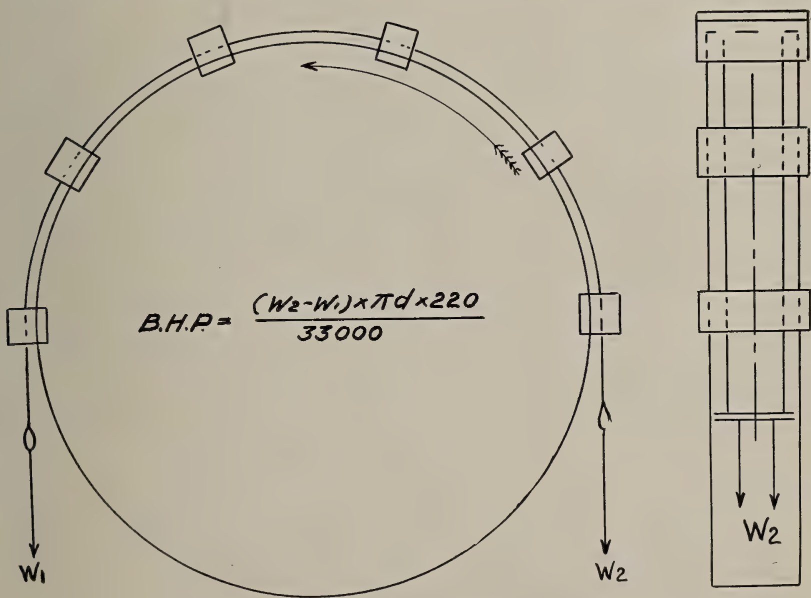

FIG. 2—Showing Adjustment of Brake.

the compression is not good, trouble may be looked for at either of the valves or the gaskets in the admission valve.

In this engine there is a vent valve placed in front of the exhaust, the opening of which, when the engine is running, allows the cylinder to become practically free from all burnt gases. This aids in overcoming pre-ignition, due to hot gases igniting the incoming charge. It has a tendency to become gummed very easily, and this foreign substance is difficult to eradicate. We wait until closing down and open the valve to allow the engine to blow out the mixture.

If the fire gets very hot due to heavy load or from blowing a long time at starting, it bakes considerably. This must be kept broken up, which also helps to prevent the fire "hanging" by keeping the coal compact, insuring more uniform gas.

When the fire becomes hot, it often causes the vaporizer to boil, emitting great quantities of steam, at times enough to supply the suction due to the engine running. This means that practically all steam is drawn through the hot fire and hence we get a gas which is very rich in hydrogen, which explodes very quickly. At such times, unless more air is admitted into the mixture, or the spark retarded, we have an occurrence known as pre-ignition. The same trouble is caused by shaking the grate when it is still in good condition. The hot coals fall through into the water in the ash pan and cause a large quantity of steam to be formed. In the ordinary running we have noticed a "knocking" or "pounding" in the cylinder. This is due to high compression pressure, and it places a very heavy strain on the crank and connecting rod. It is caused by the mixture being too rich for the spark position, and can be remedied by retarding the spark, or better and with more economy, reducing the richness of the mixture by opening the air valve.

Our spark plug required some repairing and in doing so a little asbestos was left in a hole exposed to the heat. After starting we noticed a good deal of pre-ignition. On examination we found the

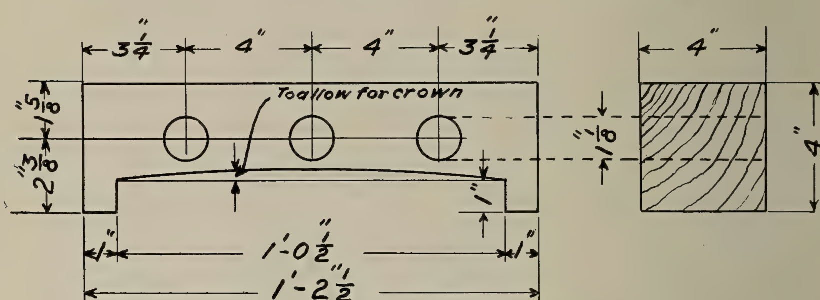

FIG. 3—Brake Shoes Used in Test.

asbestos to be the cause, and upon removing it no further trouble ensued. This emphasizes the care which must be taken to allow no foreign material to enter the cylinder and clearance chamber.

When shutting down allow only enough draft through the producer to keep the fire alive, otherwise there will be large standing losses in fuel. Also see that all water is turned off except into the vaporizer, which must be kept full.

Tests

After the engine was started and had been running for a short time we wished to test it to see if it actually was up to its rating. We had no actual load sufficient for the purpose. One had to be devised. As this may be helpful, at least suggestive, to one in a similar position, a detailed description follows.

We first took an ordinary coal oil barrel and nailed three side blocks on the inside of it at the top, approximately 120 degrees apart. Into this was hung three pieces of ½-inch gas pipe, connected

to the three phases of the generator through the switch board. The barrel was filled with water to cover the ends of the pipes about one inch. The plant was started up and brought to speed. With the field as small as possible giving us approximately 500 volts, the line switch was thrown in. The voltage dropped a little and the load was approximately 10 amperes per phase, after the phases were balanced by getting the pipes equal distance from one another. In a short time the water began to boil, causing considerable noise. Soon the effect of the evaporation began to be apparent in the current lessening and voltage rising. At this point we adjusted the rheostat, raising the voltage and thus increasing the load. In a very short time we were able to shut down the engine by overloading. At this point the voltage was approximately 1900 volts and the noise at the barrel was almost deafening due to the violent boiling. At no time was there any tendency whatever for the terminals to arc across. With the addition of a little water flowing in we could hold the load practically constant and thus maintain continuous operation.

From our readings we found the load on the generator, and estimating the losses due to efficiency of the generator, the load on the exciter and loss in belts, we approximated the B.H.P. of the engine. As the result was below rating, it was decided to make a brake test. This also proved very successful and interesting, and a description may be helpful.

In making the brake three pieces of one inch rope were used, held in their relative positions on the wheel by six pieces of wood as shown in Fig. 2. These pieces were nailed to the rope to prevent them drawing out of place. The ends of the rope were fastened to a short piece of pipe, all three ropes being the same length. These pipes made a convenient place upon which to hang the weights required for loading.

For weights anything solid was used, anvils, hammers, etc., being our choice, the weight of each piece being known. Two 25-pound spring balances were also obtained to allow for readings. When placed on the wheel we tied it down so as there would be no danger of it going over.

Once the engine was started we greased the wheel and then loaded it up. We had it well loaded for two hours and owing to the great weight of the wheel it was just warm when the test was completed. At any time during the test we could easily cause the engine to shut down due to overloading. Altogether the test was very satisfactory and our first test through the generator was found approximately correct.

In these two tests the cost of material was only trifling, the work was interesting and the results obtained were sufficiently accurate for our purpose.

THE GRADUATES IN PITTSBURG

The annual meeting of the University of Toronto Club of Pittsburg was held at the Fort Pitt Hotel on Thursday, January 4th, 1912. Mr. A. R. Raymer, '84, gave an interesting talk on the new Beaver Bridge, built by the McClintic-Marshall Construction Co., for the P. & L. E. R. R., over the Ohio River at Beaver, Pa. This bridge, involving the most modern principles of cantilever construction, formed a very interesting subject.

The structure consists of a main span of 769 feet, with 320-foot anchor arms and a 370-foot approach span. The trusses are 34 feet 6 ins. from centre to centre, accommodating four gauntleted tracks. The total weight of the structure is 18,000 tons. The work in both shop and field was done with such care that at the final closing the extreme points were within one-eighth of an inch, both horizontally and vertically, of the figured positions, and there was not a single back charge from the field to the office or shop.

The officers of the Club for the year 1912 include, president, Gardener Alison, '03; vice-president, H. O. Hill, '07, and secretary-treasurer M. L. Miller, '03, 206 Suburban Ave., Pittsburg, Pa.

WHAT OUR GRADUATES ARE DOING

This section is conducted with a double object in view : first to give the graduates professional news of each other ; second, to give the undergraduates an idea of the possibles fields of employment open to them in the future.

F. W. Harrison, '05, is engaged as assistant to designing engineer, Brooklyn Edison Co., Brooklyn, N.Y.

Geo. E. Quance, '07, is secretary-treasurer of the enterprise Gas Co., Limited, and of the Delhi Light and Power Co., Limited, Delhi, Ont.

Chas. J. Murphy, '06, is chief engineer of the Crows' Nest Pass Coal Co., Fernie, B.C.

A. H. Arens, '06, is resident engineer for the Inverness Ry. & Coal Co., Inverness, N.S., in charge of mine surveying and mechanical drafting, etc.

J. A. Mackenzie, '06, and F. C. Broadfoot, '06, are engaged in engineering and contracting work in Vancouver, B.C., under the firm name of Mackenzie, Broadfoot and Johnston.

R. E. Pettingills, '06, is in Port Colborne, Ont., as chemist for the Canada Cement Co., Limited.

Wm. Snaith, '07, is secretary of the Canadian Cement and Concrete Association, and assistant engineer to Frank Barber, '06, York County engineer.

H. O. Hill, '07, of the Riter-Conley Manufacturing Co., Pittsburg, is at present in charge of the erection work of a six million cu. ft. capacity gas holder and foundations at Pittsburg.

APPLIED SCIENCE

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EDITORIAL

THE LECTURE ON SCIENTIFIC MANAGEMENT

The meeting of the Engineering Society on Friday, March 8th, was by far the most successful of the year, and members of the staff whose close adherence to the Society has extended through many years, have termed it the most important meeting the Society has ever held. The speaker was impressed at the outset with the great interest taken in "Scientific Management" at the University of Toronto, suggested by an audience of well over 1,000. Among them were representatives of dozens of Toronto's industrial and manufacturing firms, an equally good representation of graduates, and a record turn-out of undergraduates. A number of students from other faculties were also in attendance, among whom were a few of the ladies in the political economy course.

As an indication of the speaker's ability to accelerate and maintain the interest shown, it is but necessary to observe that at

the end of two hours, a smaller part of which was occupied in discussion, the attention of his audience was so completely held that the adjournment seemed premature. A motion to adjourn, invariably producing the customary observation of the hour, does not often create surprise as it did at the conclusion of Mr. Gilbreth's lecture. The speaker did not adhere to his paper throughout, as it appears in this issue, but relapsed, oftentimes, into necessary elementary explanations for the students' benefit. These, supplemented by the paper as it appears, form a most valuable forerunner to a study of the subject and increase materially the value of the afternoon's investigations to all interested.

Directly after the meeting the executive entertained the speaker, together with a few members of the staff, at a little informal dinner at the Engineers' Club. It is regrettable that the entire audience of the afternoon could not have received the benefit of the discussion which accompanied the affair. The great scope of the subject was broadened time after time by our guest narrating experiences gained in his twenty-eight years of study and investigation. For instance, Mr. Gilbreth is at present deeply occupied in the study of its application to surgery, and his brief stay in this city was largely taken up by visits to our hospitals, to witness surgical operations. He is interested in the scientific arrangement of instruments, utensils, etc., around the operating table, with a view to improvement that will be life-saving in its effect perhaps, and, at least, less nerve-straining upon attendants. In several American cities the object of his endeavours is being embraced by the medical professions as the beginning of an enormous aid to the science.

Mr. Gilbreth, in the presence of a number of the members of the staff, strongly advised the study of "Scientific Management" as part of the curriculum in the Faculty of Applied Science, pointing out that one of the most valuable assets that a graduate can have is the habit of doing promptly, and to the best of his ability, the work set before him. With this habit and reasonable intelligence, he can make good progress. Combining with this the advantages of one of our courses in engineering, there is every chance of advancement, but, in Mr. Gilbreth's opinion, the habits of industry upon which success is contingent should be scientifically studied in every technical institution from the industrial school to the university.

TWELVE ISSUES PER YEAR

The February issue of *Applied Science* announced that it proposed to extend its publications to just twice as many issues per year. Having met with favor from all sources, the work will be undertaken. Most encouraging have been the opinions of graduates on the matter. These letters assure the journal of their support.

As a part of its new undertaking, *Applied Science* will double its efforts to bring closer together the undergraduate with the

engineering profession, on the other hand, and the graduate with the University, on the other. This is in the best interests of all concerned, and, while the co-operation from every side is solicited, the " School " man, whether student or alumnus, is looked upon to consider this publication something more than the up-to-date engineering journal it hopes to become. *Applied Science* must be, to him, a journal with his interest always before it, as ready to receive his criticism as his approval.

MONTREAL GRADUATES GATHER

On Thursday, February 16th, the graduates of the Faculty of Applied Science of Toronto University resident in Montreal held a dinner at Cooper's Restaurant, and appointed officers for the ensuing year to arrange for other meetings of a similar nature. For a number of years this scheme has often been agitated, but the present occasion is the first instance that the question has been brought to a successful issue. A temporary committee undertook the arrangements and the hearty response was an emphatic indication of the popularity of the movement.

About thirty-five assembled and Mr. G. H. Duggan, general manager of the Dominion Bridge Company, the senior graduate of the evening, acted as chairman. With him were seated Walter J. Francis, H. Rolph, D. C. Tennant, J. A. DeCew and Alan S. MacDougall.

After the king's health had been drunk, and our own dean remembered in the same manner, a permanent organization was effected with the following officers:

President—G. H. Duggan.
Vice-President—W. D. Black.
Secretary-treasurer—H. W. Fairlie.
Entertainment Committee—J. A. DeCew, L. R. Wilson, W. D. Black, H. W. Fairlie.

The nominations and "suggestions" were interspersed with many memories of days spent in the "best school of all" while DeCew and Tennant thrashed to a satisfactory decision that Billy Grant was the real author of "Toike Oike." This was a question beyond Rolph's depth, and before he could be "shown," the now famous rallying cry had to be written out and the spelling all elucidated.

DeCew's abilities as a raconteur were greatly relished in his descriptions of the days when deep-seated was the belief that

"None but the righteous shall be saved"

with drafting board and tee-square accompaniment. However, his memories rather tended to show that some of the senior men—yes, some of those present—were no improved addition to later generations.

Afterwards a very pleasant social hour was spent in the renewa

of old acquaintances, as well as in the making of many new ones, for the senior men lead by Francis, Duggan and Rolph, proved themselves the best of mixers.

"Dolly" Black, showing all the good effects of a benedict's life, did much to make the evening a success. Dundass, who has lost much of that "Monday-the-last-date-to-accept-lab.-reports" expression, led the bridge contingent, whose presence was a guarantee of the evening's success.

A number of our most prominent graduates were unable to be present, among them were R. A. Ross, J. M. Robertson, J. M. R. Fairbairn, N. M. Lash and H. V. Haighte. However, all sent messages voicing their enthusiasm in the movement, and expressing their best wishes for its success.

It is the intention of the committee to hold these gatherings at frequent intervals, and to all "School" men in Montreal and vicinity a hearty invitation is extended. It is hoped that every graduate in the district will ally himself with this association and help make it a strong factor in the university graduate life of Montreal. In Pittsburg and other centres organizations of this nature have already proved their popularity with the men who still look back with pleasure to the days when

"The 'School' could lick them all"

and there is no reason why the Montreal men cannot share in the same success in their undertaking.

THE ELECTRICAL CLUB

The Electrical Club excursion to Peterboro was most successful. The object of the excursion was to visit the works of the Canadian General Electric Co., which are situated there. Representatives of the company were at the station to meet the train and provided street cars to take the visitors to the hotel. Here, as guests of the company, a first-class dinner was provided and full justice was done to it. After dinner the works were visited, and with several of the company's engineers in charge of the various parties a most profitable time was spent in the various departments of this large works.

Several large generators similar to those installed by this company at Niagara Falls were in the course of construction and were of great interest to the visitors. It was also interesting to notice the large amount of apparatus and machinery in course of construction for the Western provinces.

The engineers who acted as guides were painstaking in answering the many questions which were asked and explained the various processes and machines so thoroughly and willingly that the visit to every department was of great interest and value to all.

One of the most pleasant features of the visit was in meeting a number of School men who are at present employed by this company.

About half of the men had to return to Toronto on the train leaving Peterboro at 4.28 p.m. and cars were provided to take them to the station. A number of the men remained over Saturday and visited several power plants of interest, including the Auburn Power Co., the city pumping plant and the power plant of the Canadian General Electric Co.

Professors Angus and Rosebrugh accompanied the Club, making a party of about forty-five.

At the regular meeting of the Electrical Club last Thursday evening, Mr. J. M. Barr gave a paper on the city waterworks system. Mr. Barr is a graduate of Glasgow University, and assistant engineer in the waterworks department.

The speaker first gave an excellent outline of the complete system showing the functions of the various pumping plants situated on the Island and in the city.

The remainder of the paper dealt with the several types of pumps in use. Mr. Barr described, at considerable length, the operation, construction and relative advantages of the two types of steam plunger pumps in use at the John Street plant. The steam pumps in the old plant are horizontal cross compound while the new pumps are vertical triple-expansion with an over-all height of fifty feet. It was pointed out that these new pumps are among the most efficient in existence. There are two of them in operation at the John Street plant, each having a capacity of 15,000,000 gallons in twenty-four hours. The old pumps have a capacity of 10,000,000 gallons in twenty-four hours. The High Level Pumping Plant also has two of the new steam pumps, but they are smaller than those at John Street.

The speaker also described the steam fire pumps which are at the lower station. These pumps are of the turbine type driven by steam turbines, and are capable of maintaining a pressure of 300 pounds in the high pressure fire system.

An interesting description was given of the new turbine pumps which have been installed at the various stations and are operated by hydro-electric power.

The city is well equipped with the means for pumping water, but is beginning to feel the need of more mains to distribute the water throughout the city.

Mr. Barr's paper was greatly appreciated by all who were fortunate enough to be present at the meeting, and a hearty vote of thanks was extended to him.

Professor Angus, who has tested all of the new steam pumps for the city, made a few interesting and instructive remarks regarding them. Mr. Randall, superintendent of the waterworks system, was also present and spoke a few words. A very instructive outline of the performance of turbine pumps was given by Mr. Allen, representative of the John McDougall Co.

TITLES OF THESES, DEPARTMENT OF ARCHITECTURE

J. H. Craig—Design of Legislative Buildings for a Canadian Province.
H. H. Madill—Design of Parliament Buildings.
H. Pullan—Design for a Synagogue.
E. V. Reid—A Terminal Railway Station.
P. Sheard—Design for Theatre.

WHAT OUR GRADUATES ARE DOING

C. B. Jackson, '07, is employed by the C. Everett Clock Co., of Kenilworth, Ill., as chief engineer and head of estimating department.

E. R. Smithrim, '07, is superintendent of the Watrous Electric Light, Power & Traction Co., Limited, Watrous, Sask.

D. J. McGugan, '07, is engaged in engineering work and surveying for the firm of Hill & Burnett, New Westminster, B.C.

G. H. Broughton, '07, is manager of the People's Trust Co., Limited, Penticton, B.C.

W. G. McGeorge, '08, is carrying on a general engineering and surveying practice at Chatham, Ont.

S. B. Osler, '08, is in charge of high tension pole line work and sub-station work with the Midland Construction Co., for Smith Kerry & Chace.

H. C. Doorly, '08, is assistant engineer for the Jenckes Machine Co., Limited, St. Catharines, Ont.

N. G. Madge, '08, is chief chemist for the Continental Rubber Co., of New York.

J. St. Lawrence, '08, is superintendent of the engine shops for the Erie City Iron Works, Erie, Pa.

C. N. Danks, '09, is in the engineering department of the Canadian Rand Company, Limited, engaged in the design of air compressors and hoisting engines.

D. S. Stayner, '09, is engaged in the city engineer's office, Toronto, in the department of railways, bridges, and docks, as resident engineer on Ashbridge's Bay docks.

C. A. Morris, '09, is mine surveyor for the Canadian Copper Co. at Copper Cliff, Ont.

J. E. Underwood, '09, has recently become a member of the firm of McArthur & Murphy, consulting engineers, Saskatoon, Sask.

J. A. Baird, '10, is with Alexander Baird, O.L.S., as assistant land surveying and municipal drainage and reclamation work, also bridge construction in Western Ontario.

W. S. Mackenzie, '11, is with the Canadian Linderman Co., of Woodstock, as tester and installer of woodworking machinery.

L. W. Rothery, '11, is superintendent of construction for the Tri-State Railway & Electric Co., East Liverpool, Ohio.

F. H. Downing, '11, is erecting engineer for the Manitoba Bridge & Iron Works, and at present in charge of the erection of transmission equipment in the National Transcontinental Railway shops near Winnipeg.

THE ENGINEERING SOCIETY EXECUTIVE, 1911-12

Top row—A. A. McQueen (Corr. Secretary), F. G. Matthews, H. O. Heaton, F. C. Mechin, R. F. B. Wood, W. G. T. Wright, R. D. Galbraith
Bottom row—H. Irwin, B.A.Sc. (Gen. Secretary), J. E. Ritchie (Vice-Pres.), R. J. Fuller (1st Vice-Pres.), W. B. McPherson (President), C. F. Elliott (Treas.), K. S. Maclachlan (Vice-Pres.), G. J. Mickler, (Vice-Pres.)

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